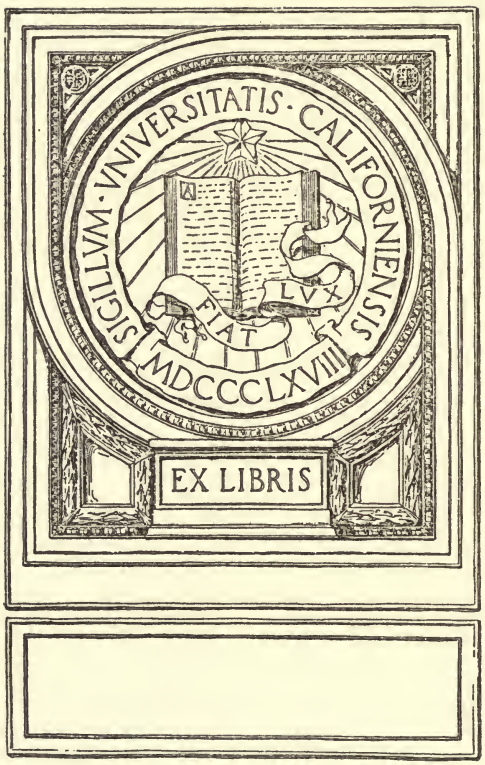
COTTON TEXTILE FABRICATION

ROBERTS BEAUMONT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PITMAN'S TEXTILE INDUSTRIES SERIES

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UNION TEXTILE FABRICATION

UNION TEXTILE FABRICATION

WITH NUMEROUS ORIGINAL DIAGRAMS, SECTIONAL DRAWINGS, AND PHOTOGRAPHIC RE-PRODUCTIONS OF SPUN AND WOVEN SPECIMENS IN THE TEXT

BY

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London

Sir Isaac Pitman & Sons, Ltd., 1 Amen Corner, E.C.4

(Incorporating Whittaker & Co.)

Bath, Melbourne and New York

TS 1445
B4

Printed by Sir Isaac Pitman
& Sons, Ltd., London, Bath,
Melbourne and New York

G. E. P.

PREFACE

Union Textile Fabrication touches, in its technological aspects and interests, the many grades and branches of Spun and Woven manufacture. It is suggestive, under analysis, of the means and processes by which augmented industrial efficiency and growth are realizable ; and also of the spheres of textile activity pregnant for technical and scientific research. The subject, when thus viewed, assumes proportions and bearings of paramount significance to the practitioner, the manufacturer, and the investigator, whether distinctly associated with the Cotton, the Wool, the Flax, or the Silk Trade.

Modern manufacturing practice demands, in the development of Union Fabrication, trained faculty and inventive resourcefulness in the unification of the strata and phenomena embodied in the factory routine, and methods, allied with the respective phases of the Spinning, Weaving, Dyeing and Finishing Industries.

This fact has led to the plan and compass of the present treatise, in which the subject matter is divided into three principal Sections—

I. Bi-fibred Manufactures—
- " Yarn and Fabric "
- " Colourization "
- " Textural Toning," and
- " Pattern Origination "

II. Compound-Yarn Fabrics—
- " Productive Schemes "
- " Textural Studies," and
- " Multi-fold Types "

III. Woven Unions—
- " Looming Principles "
- " Textures Light in Construction," and
- " Structural Schemes—Cloths substantial in Build "

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Each Section is a composite study, representative of a specialized form of practice, but it is in the effective co-ordination of one branch of work with another on which the nature and success of the manufactured achievement depends. Thus the practice in the admixture, in yarn preparation, of filaments of different tinting values and qualities, treated of in Section I, provides the ingredients of the fabric product; and these determine the colour tone, pattern characteristics, and tensile and wearing standards of the finished texture. The systems of blending animal, plant, and artificial fibres to yield yarns economic in construction, and of a definite textural and tinted property, are, therefore, dealt with in their theoretical and applied relations. Stress is laid upon the active co-operation of the chemical and dyeing expert with the textile specialist, in establishing a commercial colourization scheme, such as that detailed in Chapter II, and which has been framed on original investigation and experiment.

It is shown how the mechanical equipment, and operative and process routine, in manufacturing, are subservient to the production of a wide range and assortment of union yarns, which are considered in their application to mixed fabrics—structurally illustrated—of cotton and wool, cotton and flax, cotton and worsted, and silk, wool, and ramie, etc. Classified working data are given of such fabrics in light, medium and heavy structures, with the dyeing and finishing treatment to be observed in their manufacture.

Design relative to Cloth Construction, and Pattern Origination, is exhibited in Chapter IV as a resultant of filament blending, yarn spinning, and of tinting in piece-dyeing. A comparatively new phase of patternwork is here suggested and elaborated. Examples in style formation in two, three, and four shades are dissected; and the degree of tone differentiation feasible, in the fabric, as a derivative of the several classes of fibre combined in the arrangement, or grouping, of the warp and weft yarns, is explained in reference to typical woven specimens.

A fundamental source of textural variation obtains in the mechanical methods of acquiring folded union yarns, in which the thread units employed differ in material composition.

The PRODUCTIVE SCHEMES, which this basis of manufacture offers, are adjustable to each description of union texture, that is, to admixed woollen, cotton, worsted, linen, silk and ramie fabrics. Hence the structural varieties of Union Twists are analytically examined, and their apportionment described, in the making of multi-ply yarn cloths dissimilar in (1) fibre composition, (2) thickness, (3) quality and softness, and (4) in weave and colour attributes. In illustration of the technicalities involved, tabulated settings are supplied of fabrics woven in twist yarns, consisting of woollen and cotton, worsted and cotton, linen and cotton, and worsted, cotton and silk.

The function of Weave, in the acquirement of standard and special makes of this class of unions, is also shown, with explanations on the principles of modifying the folded-yarn structure in developing distinctive pattern features in the finished goods. The two latter subjects are treated of at some length, and exemplified by selected woven types, under TEXTURAL STUDIES.

As folded yarns may be diversified in counts and in surface features in addition to being varied in filament quality, they provide a field for textile experiment, the traversing of which results in the manufacture of important descriptions of commercial fabrics, economic and sound in build. Such serial investigations—formulated and carried out in the amplification of this branch of woven technology—as are embodied in the book, bear more especially, in Chapters VI and VII, on the origination of "plain" and "fancy" union cloths of a woollen, worsted, cotton, linen, and of a silk character.

Throughout the treatise research, in the fabrication of bi-fibred yarns and textures, is demonstrated and revealed as subdivisible into—

I. Technological research in the manufacture of bi-fibred warp and weft yarns, and of bi-fibred woven and knitted structures, inclusive of schemes of experimental work in the qualitative, structural, and economic products to be acquired, in the respective classes and groups of textile fibres, by varying (*a*) the quantitative percentages of the materials blended; and (*b*) the systems, methods and practices of thread and fabric construction.

II. Research, relative to chemical, physical, and microscopic investigations, to determine (*a*) the properties of fibres with a view to their successful utilization; and (*b*) the quality, durability, tensile strength, and intrinsic clothing value of the manufactured cloth.

III. Research in tinctorial chemistry, or in the dyeing of materials of dissimilar colouring affinities—in the yarn or in the felted, knitted, or woven result—for determining the range and diversity of tinting, and design effects, procurable as a consequence of the form, and proportionate quantities, in which the several varieties of fibre are amalgamated in the processes of textile production.

IV. Chemical and technological research in the finishing, lustring, or dressing of the spun, woven, or other kind of manufacture.

Any scheme of UNION FABRICATION to be of general serviceability must be adaptable to the making of fabrics differing in weight per yard, wearing strength, and surface style. All the basic principles of manufacture are, therefore, treated of in reference to TEXTURES LIGHT IN CONSTRUCTION, and to CLOTHS SUBSTANTIAL IN BUILD. In the former, dress fabrics—lustres, alpacas, crepons, union silks, cottons and linens—and also certain grades of decorative textures are comprised; and in the latter are included all the heavier types of union cloths, such as overcoatings, rugs, blankets, milled goods, and multi-ply fabric structures.

The study and dissection of the Union Textile Industry here presented, have, as a dominant objective, the substitution of arbitrary rules and practices by organized technical and scientific methods, processes, and routine, in all departments of Union Yarn, and Union Cloth Manufacture, Design, Tinting, and Finishing.

In the effective framing and issue of the book, I desire to express my appreciation of the help courteously rendered by the Publishers.

R. B.

HEADINGLEY, LEEDS.
17*th December*, 1919.

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SECTION I

BI-FIBRED MANUFACTURES

UNION TEXTILE FABRICATION

CHAPTER I

Yarn and Fabric

1.—Group Types of Union Manufactures. 2.—Relative Filament Values. 3.—Bi-fibred Yarn Production. 4.—Mixtures of Cotton and Wool. 5.—Technicalities—Woollen Practice. 6.—Staple Equality. 7.—Union Worsted Yarn Preparation. 8.—Fineness of Fibre and Spinning Property. 9.—Function and Use of Cotton in Carded and Combed Yarns. 10.—Blends—Wool and Cotton. 11.—Blends—Cotton and Wool. 12.—Qualitative Factors—Bi-fibred Yarns. 13.—Union Yarns—Systems of Modifying. 14.—Folded-Yarn Unions. 15.—Bi-fibred and Union-Twist Yarns Compared. 16.—Two Varieties of Multi-fold Union Threads. 17.—Ordinary Category of Union Twists. 18.—Factors Controlling Filament Percentages and Yarn Counts. 19.—Union Yarns and Quality of Manufactured Product. 20.—Loom-made Unions. 21.—Textural Methods of Combining Yarns Spun of Different Materials. 22.—Comparison of Folded-Yarn and Woven Unions. 23.—Utility of Cotton as Warp Yarn in Union Manufactures. 24.—Varieties of Woollen and Worsted Weft Yarns.

1. *Group Types of Union Manufactures.*—There are three typical groups of union manufactures, namely—

I. Bi- and Multi-fibred Yarns, employed in hosiery, frame- and loom-made textures, and resulting from the admixture, in the processes of thread preparation, of several varieties of fibrous material, such as, animal, plant, and mineral filaments, comprising wool and wool substitutes and cotton ; wool and silk waste ; cotton and flax or cotton and rhea or ramie ; wool, cotton and silk noils ; and hair or coarse wool and asbestos.

II. Compound, Doubled or Folded Yarns, also applied in the production of knitted, lace and woven structures, and formed by twisting, into one yarn unit, separate threads of (*a*) cotton and woollen or worsted ; (*b*) cotton and mohair or alpaca ;

1—(1745)

(*c*) linen and silk; (*d*) cotton and silk; (*e*) woollen or worsted, cotton, and silk or artificial silk; and of (*f*) linen or ramie, worsted, and "organzine," "trame" or "spun" silk.

III. Woven, Lace or Knitted Fabrics, consisting of two or more kinds of yarn, as cotton and woollen; cotton and silk; linen and silk; cotton and worsted, or cotton and cashmere, alpaca or mohair; worsted, cotton and silk, etc.

In the first instance, the union product is acquired by combining at least two distinct classes of fibre in spinning practice; in the second, by combining, in the operation of folding or twisting, a selected number of threads made of different materials and by different systems of yarn construction; and in the third, by combining, in weaving, knitting or lace making, several yarn structures distinguished from each other in filament composition. Three methods of fabrication are involved applicable, respectively, to (1) union-spun yarns, (2) union-folded yarns, and (3) to union-yarn fabrics. As however, bi-fibre and multi-ply union yarns are both used in textual production, each method of work is common to union-cloth manufacture.

2. *Relative Filament Values.*—The quantitative values of the classified filament ingredients are determined, in Group I, by the percentages of the materials blended in the routine of spinning—these conforming with the quality and grade of yarn required. But, in Group II, the fibrous ratios are fixed by the relative diameters and lengths (*i.e.*, weight equivalents) of the special threads folded together in producing the compound yarn; and, in Group III, by the counts and the ends per inch in the fabric of the various sorts of yarns utilized. With the practice of filament admixture thus diversified, the effects in the manufactured texture differ in each class of union fabrication. To obtain, for example, a cloth in which the fibrous products are promiscuously but consistently intermingled, the union-yarn practice is the best adapted. It results in a thread formation equally and symmetrically composed of every class of fibre in the raw materials

applied. This profusely-mixed filament property is imparted to the woven and finished manufacture. On the other hand, in the assortment of union-folded yarns, the individual threads retain their distinctive characteristics and structural features in the loom-made product. The intermixture of the fibrous varieties is effectively carried out, giving the proportionate quantities of each sort of fibre desired, but, in the texture, their specific qualities and effects are clearly emphasized by the thread-like condition in which they occur. Each separate yarn in the multi-ply threads is traceable, and with it the material—cotton, wool, silk, etc.—of which it is formed; whereas, in the union-spun yarn texture, the different materials are only observed as commingled elements in the yarn substance of which the cloth is made. Other and pronounced demarcations obtain in the grouping and combination of the material factors in union woven fabrics. Here each variety of thread, such as linen and silk, cotton and alpaca, woollen and cotton, has a special function in the weaving process, so that dissimilar kinds of yarn may be used in the warp, and in the weft, for the face, the centre, and back of the fabric. This union principle of manufacture also provides for the application of one class of yarn to the ground and of other classes of yarns to the design or pattern in the piece; and for the origination of economic cloth structures, by the employment of yarns of distinctive materials and thicknesses for the formation of the face, underside, or other specific positions in the texture.

3. *Bi-fibred Yarn Production.*—Bi- or multi-fibred yarns are strictly composed of fibres differing in physical structure, chemical analysis, and in technical properties for textile manufacturing purposes; or of such filament classifications as specified in Group I. Admixtures or blends of wool, mungo, shoddy, noils, flocks and other wool substitutes, or the combination of several sorts of wool, cotton or flax, do not yield union yarns in the sense defined. The fundamental factor is the distinction in the qualities and structural nature of the

fibres selected. This is the source of the compound yarn acquired and of the union cloth manufactured.

Thus understood a mixture-fibred yarn, made of cotton and wool, gives a union texture corresponding in filament quantitative composition to a fabric woven with cotton and woollen yarns. But, as explained, in one cloth the two materials are so assimilated as to result in one fibrous substance; while, in the other, the cotton and wool ingredients remain separate units, or in the yarn condition in which they are interlaced in the operation of weaving. Ordinarily, a union-yarn production, consisting of animal and vegetable fibre, is intended to form a fabric having the surface features, and, as far as feasible, the serviceable characteristics of a cloth made of yarns composed of the former variety of fibre. If, for instance, the fibrous materials should be wool and cotton, the idea is a union manufacture resembling a " pure " woollen or a " solid " worsted, according to the scheme of yarn preparation practised. Obviously, this is only so in degree, for with the increase of the percentage of cotton and the decrease of the percentage of wool in the mixture, the wool value and quality of the finished product are necessarily diminished. But, having this objective in view, the complete amalgamation of the filament units is the productive standard and industrial result to be attained.

4. *Mixtures of Cotton and Wool.*—In the admixture of cotton and wool, which may be taken as illustrative of the yarn structures comprised, two systems of blending are applied. If the intention is the manufacture of a "carded-yarn" fabric, the combination of the materials is effected in the operations of teazing, scribbling and carding; and if a "combed-yarn" fabric, in the processes of drawing, with a preliminary mixing of the two varieties of fibre in the *mélangeur* or blending machine. Success, in both systems, is dependent on the average staple lengths of the wool and cotton, the average fineness of the fibres in each, and on the general adaptability of the different materials for perfect affiliation, one with the

other, in the mechanical work of thread construction. Irregular lengths of fibre in the wool, or an excessive aggregate staple measurement as compared with that of the cotton, renders the thorough and effective admixture of the materials difficult in both the carding and drawing methods of procedure.

The amount of carding surface in the machinery employed may lessen the influence of the disparity between the staple lengths, but it does not rectify or eliminate the defects which arise from this cause. In the treatment of the longer and freer wool staple, the shorter and closer cotton staple is not sufficiently opened, nor are the individual fibres satisfactorily intermingled. The cotton units in such a mixture of materials develop a disposition to cluster, and also to pass in this state into the carded sliver. Hence all the irregularities in yarn structure usually traceable to imperfect carding—nappiness and unevenness in the condensed thread, and a spun thread variable in filament density, admixture and composition—are liable to ensue from the selection of extremes in staple lengths when animal and vegetable fibres are blended, carded, and made into one quality of yarn.

5. *Technicalities—Woollen Practice.*—Assuming that materials of a suitable character are combined, the principal technicalities requiring attention, in the manufacture of union yarns equalized in fibre consistency, relate to the construction of the carding machines used; the setting of the parts of the scribbler, the intermediate, carder and condenser; and the covering of the feed and delivery rollers, the cylinders, workers, strippers, doffers and other rollers with card clothing of the correct "counts" and "crown" for the efficient treatment of the wool and cotton staples.

First, three machines per set are preferable to two, though the latter may coincide in carding surface with the former, inasmuch as the third machine provides for an extra transference of the material, in the process of sliver-making, by its removal from the intermediate and conveyance on to the carder. This arrangement, in presenting the fibres in a

changed relation to the feed rollers from that in which they are cleared from the cylinder of the preceding machine, increases the amount of filament straightening, crossing and distribution, and this is favourable to the complete mixing of different varieties of raw material in yarn production.

Second, the setting practice must enable the wool and the cotton to be each fully separated and re-combined fibre by fibre, and also cleanly conveyed from one series of active rollers to another. A mean setting of the parts of the machines, betwixt the closeness or gauge applicable in the working of either material independently, is advantageous. It must be progressive, or augment in fineness of gauge, from worker to worker and from cylinder to cylinder, reaching a higher carding efficiency in advancing from scribbler to intermediate and from the latter to the carder.

Third, the counts of the card clothing should be systematically graduated or raised in fineness at each succeeding working and stripping point and in each machine in the set, effecting with the setting practice, a consistently more searching carding action, from the entrance of the material into the first machine to its clearance from the cylinder of the carder as a web of composite and cohesive fibres, and of equal flexibility in all portions of its structural formation. For dividing this web into continuous strips of like widths and filament density, the tape system of condensing is convenient on account of the number of slivers it affords the means of producing, and also on account of the adaptability of the system to the preparation of the counts of sliver appropriate for medium and fine spinning.*

6. *Staple Equality.*—Equality, or rather approximate evenness, in staple length, is valuable in the construction of combed or worsted union yarns, more especially in the drawing operations in which the mixing of the different kinds of slivers is carried out. Up to and including the process of combing each variety of fibre, such as wool and cotton, or wool and silk waste, is treated separately. This practice has certain advantages

* See Chapter III of *Woollen and Worsted*, by the same Author.

over the carded yarn principle. It provides a prepared material in which the fibrous units are suitably classified and grouped in parallel relation, the shorter and irregular lengths of fibre being removed in the combing action. The materials—wool, cotton or other fibre—when in the form of combed tops or slubbings, are in a useful condition for blending with each other and in definite proportionate quantities.

Should, however, there be a marked discrepancy in the staple lengths of the respective slubbings, the operation of drawing would present a number of technical problems. This will be understood from the nature and objects of the drawing routine—the straightening of each class of fibre and levelling of the compound sliver by repeated attenuation and successive doublings. It is not only sought to prepare a roving of wool and cotton with the materials correctly assorted, but a roving in which the several sorts of fibre are systematically evened and arranged in lineal order. Such filament conditions, in the resultant or roved thread, are attainable providing the measure of drafting, applied in each drawing frame, is simultaneously and consistently sustained by every kind of fibre combined, but not otherwise. With the mixing of staples differing in length to such a degree that the adjustment of the drafting rollers—distance from centre to centre—cannot be made to equalize the tension and action on each material, faulty sliver, roving, and yarn production would ensue. The difference between the longer and the shorter staples should not prevent the determination of a mean draft, or stretch, intermediate betwixt the two, that would be operative in drawing out and lining every variety of fibre of which the staples are composed.

7. *Union Worsted Yarn Preparation.*—Blending, for union worsted yarn, is done on the French system of drawing and spinning. By combing the several materials on the same principle as in the Heilman type of machine, a quality and structure of top sliver is obtained, whether made of wool, ramie, cotton or silk, suitable for admixture purposes. The two or more kinds of prepared-combed slubbings, selected for

combination, are, in the first instance, run together in the *mélangeur*. The multiple of union slubbings thus made for treatment at the first drawing frame, and also at subsequent frames, is modified by its combined weight per a fixed number of yards, the amount of draft in the frame, and the counts of doubled sliver required. The function of drawing is to reduce the sliver resultant by degrees, or until it becomes a roving of a suitable size for spinning. The process is identical in character in the series of five or six machines employed. It consists (1) in passing the sliver doublings between two pairs of rollers differentiated in surface velocity; (2) in carrying the material through the pins of the porcupine roller placed in an intermediate relation to the two sets of drafting rollers; and (3) in frictionally forming the mixed but levelled groups of fibres into a soft thread, by carrying them between a pair of leathers having a rotary and side-to-side movement. This system of roving preparation is, at every stage, adapted for the commingling, and length equalization, of fibrous materials differing in quality and structural properties. Not inserting a percentage of "false" twist into the slivers down the drawing, as is done on the English type of machine, is an essential gain; while the plan of conveying the slivers over a revolving pinned roller, and of converting them into a thread-like form by the oscillatory traverse of the rubbing leathers, induces a complete admixture of the different fibres with a minimum displacement of their straight-line or parallel relationship. These processes being duplicated at each drawing box, a roving is acquired composite and balanced in fibrous quality, that is of a suitable structure for spinning into a perfectly-mixed union worsted yarn.

8. *Fineness of Fibre and Spinning Property.*—Aggregate filament fineness, in the materials assorted, is of basic importance. It affects the spinning property or the counts to which the mixed yarn may be spun. Moreover, it is essential that the wool, cotton, etc., should, more or less, correspond in staple, or in diffusive and flexible features, seeing they have

to be conformable to the same mechanical work and system of yarn construction. The several sorts of filament combined should neither be modified nor deteriorated in the processes of thread making. Their original and intrinsic textile values should be accurately preserved, and it will be evident that in proportion with which they vary in the features defined, the difficulty of attaining this result will be increased. However skilfully the machinery employed in thread preparation should be manipulated, set, and speeded, the individual groups of fibre, when radically differing in carding, combing, drawing and spinning properties, would be either unsatisfactorily treated or impaired in these operations. Therefore it is imperative, if the several sorts of fibre blended are to impart their specific nature and qualities to the union manufacture, that they should have such structural characteristics in common as to render them applicable to one and the same scheme of yarn production.

9. *Function and Use of Cotton in Carded and Combed Yarns.*— Bearing these technicalities in mind, cotton may be made to contribute to the spinning property or length of wool. For union carded yarns applied to flannel, blouse and light fabrics, and also to hosiery textures, cotton is employed partially with this object, and partially on economic grounds. Wool for like reasons, or for diffusing its distinctive qualities of softness, flexibility and brightness of tone, through the union product, is mixed with cotton. In all such manufactures the negative properties of a material may be utilized for counteracting, in a degree, the positive properties of the materials with which it is blended. Cotton, for example, is effective in diminishing the shrinkage power of wool, as the latter, in combination with cotton, is effective in reducing the comparative firmness of the cotton yarn and texture.

These elements are of technical value both in manufacturing processes and in manufactured results. They add to the diversity of yarn and cloth fabrication, by making it feasible to moderate the influence of the vegetable or animal fibre, and to produce a description of unions with a woollen

or cotton bias, or an average grade of fabric betwixt the pure wool and the pure cotton manufacture.

10. *Blends—Wool and Cotton.*—On the principle that the fineness of the fibre, and the staple measurement of the materials, should be in coincidence, the following exemplify the classes of filament suitable for blending in the production of bi-fibred yarns made of wool and cotton :—

A. Carded Yarns.—(1) Fine counts, 32 to 48 yds. per dram, Australian merino clothing wool and Egyptian cotton-staple, 1 to $1\frac{5}{8}$ in. ; (2) Yarns ranging from 22 to 30 yds. per dram, English South Down and sorted Welsh wools and long-staple South American cotton, averaging 1 to $1\frac{1}{2}$ in. in length ; and (3) Yarns composed of wool substitutes—mungo chiefly—and short-stapled or Indian cotton.

B. Combed Yarns.—(1) Fine Botany counts, merino Australian or New Zealand combing wool and Sea Island cotton-staple, $1\frac{1}{2}$ to $2\frac{1}{8}$ in. ; or merino Australian lamb and Egyptian cotton ; (2) Medium counts of Botany yarns, River Plate, Buenos Ayres and Monte Video wools and strong-fibred South American cotton, averaging 1 to $1\frac{1}{2}$ in. in length ; and (3) Yarns in which a high percentage of vegetable fibre is used, made from Australian and New Zealand short-stapled combing wools and Egyptian or Brazilian cotton.

As a rule in such blends, the wool filament is designed to give the predominant character to the mixed yarn, so that it is desirable it should be of an even growth, yield satisfactorily in carding and combing, and possess elasticity and suppleness of staple. The cotton is estimable, as it is subservient in contributing to the spinning of a level, firm thread, of equalized tensility, diameter, and smoothness.

Assuming the relative proportions of the materials for the blends specified to be from 75 to 85 per cent. of wool and from 55 to 70 per cent. of wool, with relative proportionate parts of cotton, the yarns and textures obtainable from different mixtures would have the qualities and exhibit the features tabulated on pages 11 and 12.

TABLE I

ADMIXTURES OF WOOL AND COTTON—BI-FIBRED YARN MANUFACTURE

	Percentage of Wool Fibr .	Percentage of Cotton Fibre.	Yarn and Textural Features.
A.—Carded Yarns.	75–85	25–15	Yarns of a distinct wool-like nature and consistency in both (1) and (2), and applicable, in the higher counts, to flannel, blouse, dress, and costume textures, also to knitted goods. The costume cloths, when correctly made in the loom, are suitable for milled and raised finishing treatment. The medium counts of yarn (2) are serviceable in the weaving of fabrics of a moderate weight per yard adapted for wear, and for general and domestic purposes. The cotton staple does not detract from but slightly enhances the durable quality of these productions. As in (3) the materials are chiefly efficient in the spinning of thick counts, and as the wool fibre is depreciated in the processes of re-manufacture in length, elasticity, and in breaking strain, the yarns are largely employed in the manufacture of the lower varieties of medium and heavy cloths. Still, with the practice of skilful dyeing and finishing, the fabrics in these materials are of a satisfactory tensile standard, and possess a fair degree of softness and fullness of handle.
	55–70	45–30	Here the influence of the cotton fibre—(1) and (2)—is evident in the firm and compact structure of the yarns, also in the reduced flexibility of the woven goods, and in their lessened disposition to felt or mill. Textural value as to clearness in surface features, and in weave and pattern delineation, slightly improved as contrasted with that of the preceding groups of bi-fibred yarn cloths. Admixtures of the two species of fibre in these proportionate quantities—70 : 30—as likewise in the ratios of 2 : 1 and of 3 : 2, are made in the fabrication of similar but lower grades of fabrics to those described above. The yarns in (3) yield cloths perceptibly deteriorated in finishing—felting and raising—and warmth-yielding properties as compared with similar cloths consisting of yarns spun from 70 per cent. of wool and 30 per cent. of cotton. Fabrics durable but deficient in filament cover, and deteriorated in shade tone as the percentage of cotton in the blend is increased.

TABLE I

ADMIXTURES OF WOOL AND COTTON—BI-FIBRED YARN MANUFACTURE

(*continued*)

	Percentage of Wool Fibre.	Percentage of Cotton Fibre.	Yarn and Textural Features.
B Combined Yarns.	75–85	25–15	The combed union yarn is of a brighter and smoother character than the union carded yarn made of similar varieties of fibre. From both blends (1) and (2) a particularly fine quality of thread is producible. The South Sea Island cotton in (1) is a silky-stapled material, and, in these percentages, only slightly affects the full colour property of the yarn; and the South American cotton in (2) is of a sufficient length to mix profusely with the wools named, in the drawing operations. Moreover, its strong growth adds to the weaving applications of the class of mixture thread acquired. Thus, these two types of union worsted are differentiated both in the quality of the wool and cotton staple of which they are composed. In preparing the yarns on the French system of combing, drawing and spinning, the thread formation resultant closely resembles that of a pure worsted, and one which may, therefore, be employed for like grades of woven and knitted goods as the latter. It also yields textures of equivalent wearing utility to worsted yarn of the same counts, but a fraction cooler in the use for clothing.
	55–70	45–30	With the aggregation of the vegetable fibre to 30 or 45 per cent. of the materials combined in blends (3), the cotton staple imparts specific properties to the yarn manufactured. It is perceptibly harder and closer in structure. While the yarns are well-adapted, on account of their evenness and firmness, for clearly expressing weave and pattern elements, they result in fabrics which lack shrinkage value. This is attributable to the increased quantity of the cotton ingredient, and has led to the practice of setting the pieces in the loom with approximately the same number of threads and picks per inch as they are intended to present in the finished condition. The like treatment of cotton and wool of equal staple-lengths and corresponding fineness of fibre in the combing process ensures the production of a correctly-mixed roving, from which a quality of yarn is spun specially suitable for the manufacture of a large variety of blouse, dress and other thin and light textures.

11. *Blends—Cotton and Wool.*—As stated, the above varieties of bi-fibred yarns, showing an excess quantity of wool, are intended to give to the manufactured texture a woolly quality and feel. Mixture yarns are also extensively spun in which cotton is the principal and wool the secondary staple. These, however, are strictly of a cotton character, imparting to the fabric the surface features and also the handle of a cotton product, modified in softness and fibrous nature by the ratio in which the wool is blended with the cotton fibre in the materials selected.

The counts and composition of this class of cotton-and-wool mixture yarns are typified in the following table :—

TABLE II

BI-FIBRED YARNS—COTTON AND WOOL

Variety.	Cotton Counts.	Shade.	Per cent. of Wool.	Cop.
(1)	7's	Colours	25	Warp
	7's	,,	30	,,
Thicker counts	7's	Mixed	10	,,
	8's	White	10	Weft
	8's	,,	50	Pin cop
	8's	Colours	30	,,
(2)				
Any counts from 10's	16's	White or natural	5	Pin cop
to 20's cotton; any	20's	,, ,,	5	,,
per cent. of wool	16's	,, ,,	10	,,
from 5 to 30	20's	,, ,,	10	,,
	16's	,, ,,	20	,,
	20's	,, ,,	20	,,
	16's	,, ,,	25	,,
	20's	,, ,,	25	,,
	16's	,, ,,	30	,,
	20's	,, ,,	30	,,
	10's	Mixture Colours	20	,,
Any shade	20's	,, ,,	30	,,
	20's	Solid colours	30	,,
(3)				
Finer counts	23's	White	20–25	Cop
	33's	,,	20–25	,,
	23's	Natural	20–25	,,
	33's	,,	20–25	,,
	28's	White	20	Pin cop
	28's	Natural	10	,,
(4)				
Twist	6's to 21's	White	5	Twist

12. *Qualitative Factors—Bi-fibred Yarns.*—The percentage of wool in the lower counts (1) averages from 10 to 50, the yarns specified being equivalent to 23 and 26 yds. per dram, woollen counts. They are, therefore, useful in the production of medium grades of imitation all-wool goods, employing the bi-fibred yarns for both warp and weft, or a pure woollen yarn for warp, crossed with a union yarn of a similar thickness, containing, as found convenient, from 50 to 90 parts of cotton fibre. In the second sort, the 10's, 16's and 20's cotton counts correspond to 15's, 24's, and 30's worsted, making them suitable, as weft, in 2-fold 30's, 2-fold 48's and 2-fold 60's worsted-warp fabrics. If employed in this way, the proportionate value of the cotton in the weft would be variable—95, 90, 80, 75 and 70 per cent.—allowing of the goods being made with a higher or lower ratio of cotton to wool as adapted to the cost and quality of manufacture intended. For "fancy" or coloured styles of fabrics, mixture and solid shades, in 10's and 20's, or other cotton counts, consisting of 20 or 30 per cent of wool, are provided to harmonize with the fancy shades of worsted forming the warp yarn of the pieces.

The finer counts—23's, 33's, and 28's cotton = 2-fold 70's, 2-fold 100's, and 2-fold 84's worsted—are quoted as spun in the white or natural colour, and as composed of 20, 25 and 10 parts of wool to 80, 75 and 90 parts of cotton. Yarns of this fineness are used in the weaving of thin dress and like textures, in which the warp may be single or 2-fold worsted or cotton. The "twist" union threads (4) are specially serviceable for striping and pattern effects in piece-dyes mainly woven in combed-wool yarns.

13. *Union Yarns—Systems of Modifying.*—There are three forms in which the yarns, in Tables I and II, are subjective to modification—1st in the quality of the wool and cotton staple; 2nd, in the percentage values of the two varieties of material; and 3rd, in structural features—carded or combed, self-actor or frame spun. The first factor controls the yarn grade and fineness, the second the wool and cotton ingredients of the

thread, and the third the application of the yarns to textile manufacture.

In all classes of union yarn spinning, the staple lengths of the different materials require, as illustrated, to lend themselves for coherent admixture in the processes of carding and of drawing; and the two species of fibre combined must be coefficients in spinning property. These elements are of primary consideration. Yarn diameter or counts does not, however, necessarily define yarn quality for textural production. As a fine-stapled wool may, in worsted or woollen yarn making, be applied to medium or high counts, so in bi-fibred yarn spinning the materials selected are usable for yarns of dissimilar thicknesses. Trueness of quality, in the thread product, is a derivative of the nature of the raw materials. This basic factor is well exemplified in the varieties of wool and cotton in blends (1), (2) and (3) for the combed and carded threads in Table I. Yarn character and quality are here indicated as arising out of the sorts of fibre combined. Given material staples of the description in blend (1)—Section A or B—the yarn spun would be of a fine fibrous consistency, whether produced in thick or small counts, but the smallness of thread spinnable would be higher in the materials forming blend (1) than (2), and in (2) than in the materials in blend (3).

The proportionate value of the cotton and wool, in the manufacture of the yarns, is an element apart from the fineness of the fibres and the classes of staple intermingled. It determines the actual or commercial cost per lb. of a given grist of yarn, which is lessened with the decreasing ratio of wool to cotton, and by the relative price of the two materials. The quantitative use of cotton as an ingredient of the yarn has also another value, which will be subsequently examined, that of the dyeing or tinting attributes of the union thread constructed.

In reference to the third factor, it should be noted that the count of yarn practicable, from a certain combination of staples, is affected by the system of yarn production—the combed system yielding, on an average, higher results than

the carded system. With wool as the excess component of the mixture, this difference in the method of thread-spinning on the " count " limit is particularly accentuated. Thus, the maximum counts of the yarns obtainable by the carding practice may be taken as 44 to 48 yds. per dram, whereas similar varieties of fibre by combing, drawing, and frame spinning, may be made into 100's or 120's worsted, or equal to 218 and 262 yds. per dram. On the woollen principle, the admixture of cotton with wool amplifies the spinning limits, but not essentially on the worsted principle. The distinction is largely caused by the carding treatment in woollen yarn preparation being designed to use every class of filament—short, fine, curly, coarse, etc.—while the combing process, in worsted thread preparation, removes a portion of the short fibre and levels and lines the selected and longer fibres with each other. In addition, in the carded and condensed sliver, the fibrous units cross each other at a multiplicity of angles and in diverse directions, whereas in the combed and roved sliver, the fibres are not only parallel but, to a large degree, extended to their full lineal measurement, and in a sense conforming with the length of the thread. One system, the combing, attains the spinning limit of the average diameter of the fibres, whether cotton or wool; and the other system, carding, attains a yarn structure in which the fibres are promiscuously mixed and grouped but without aiming at fibre selection, attenuation, and alignment.

14. *Folded-Yarn Unions.*—Folded-yarn unions are very varied in both fibre and thread composition. The folding practice may be done in the slivers or unspun thread form, and in the roving frame or in the self-actor, but it is chiefly effected in the spun thread and in the doubling or twisting machine. The first method produces a class of mixture yarn which is a cross betwixt the bi-fibred and the folded or compound thread. If the yarn is of the worsted type, the rovings, such as cotton or flax and wool, are combined in the roving operation, being drafted, levelled, and formed into a mixed

sliver. The fibrous elements are more separate, and distinctive, one from the other, in the yarn which results than in a union worsted. When dyed slivers are used, the thread acquired is of the "marl" description. Carded slivers—woollen and cotton—are not so suitable for combination as combed slivers. The woollen principle of thread production does not provide for the admixture and the doubling of the slivers prior to spinning. The roving, on the other hand, is an intermediate product, in thread formation, between the thick, soft sliver, prepared in the drawing operations, and the spun yarn. The process of roving may in this instance be utilized in giving a compound sliver of the proper intermingled filament character for drafting and twisting; but, in combining carded slivers the doubling of the wool and cotton slivers has to be effected in the actual work of drafting and twisting on the self-actor. Still, this method of union-thread manufacture is capable of being increasingly practised and developed. It involves mechanical adjustments and alterations in the spinning machine, using special drafting rollers for each variety of sliver, and for treating the slivers as one-thread unit at the front or delivery rollers.

15. *Bi-fibred and Union-Twist Yarns Compared.*—Both the worsted and woollen practice, of doubling slivers of a special filament consistency, results in the production of a useful class of yarn, one adapted to the manufacture of different groups of textures from those producible by employing bi-fibred or folded yarns. It is a single-spun thread, with the properties of each sort of sliver used in its construction. Though the fibres of each material are evenly mingled and distributed throughout the thickness and length of the yarn, the structural features of the individual slivers, remaining more or less intact, impart quality and effect to the dyed and finished manufacture.

16. *Two Varieties of Multi-fold Union Threads.*—Bi- and multi-fold union yarns are of two principal classes, namely, "plain" and "fancy" twists of which there are several

varieties. Both types of production are made of yarns differing in counts, in material composition, turns per inch, and in methods of preparation and spinning. The ordinary or plain twist threads, of whatever thread grouping, are even in thickness and in surface characteristics, so that they may be used as a principal kind of yarn in textile fabrication. Fancy twists, as the term denotes, may be diversified in circumferential features—gimped, knopped, curled, looped, etc.—or they may be irregular in diameter, with sectional parts varied in degree of twine. For the manufacture of the generality of piece goods consisting of twist warp or weft yarns, or cloths equalized in elasticity standard and in textural details, the first type of compound thread may be employed. The second type is also used in limited forms in the weaving of dress fabrics, but it finds its main application in the development of pattern and design. Folded yarns possess and exhibit in the texture the combined attributes of the unit threads used in their formation, and it is in this sense that fancy twists prove specially serviceable in style origination. It will be shown that the effects of this class of yarn in the fabric, emphasized or subdued, vary with the counts of the constituent threads relative to the thickness of the folded yarn; and also with the colour contrasts and the shape each thread is made to assume in the compound structure.

17. *Ordinary Category of Union Twists.*—Table III (pages 19–21) contains examples in union-twist yarns of the ordinary category, varying in counts, and made of woollen and cotton, worsted and cotton, worsted and silk, cotton and silk, cotton and linen, linen and silk, and worsted, cotton and silk threads. It will be observed that the single threads differ in thickness in each description of folded yarn, and that the counts of the latter cover the principal varieties of thread used in the warp and weft of the union fabrics to which such yarns are applicable. These technicalities enable either the structure or the filament quality of the cloth to be extensively modified.

TABLE III

A—Woollen and Cotton.

No.	Counts of Twist Yarn in Skeins.	Thread Units.	Filament Percentages.
1	32·2	48 sks. woollen and 30's cotton	67·2 of wool and 32·8 of cotton fibre
2	30·2	48 „ „ 25's „	63·0 „ „ 37·0 „ „
3	24·8	40 „ „ 20's „	62·1 „ „ 37·9 „ „
4	22·0	40 „ „ 15's „	55·1 „ „ 44·9 „ „
5	18·6	30 „ „ 15's „	62·1 „ „ 37·9 „ „
6	17·0	30 „ „ 12's „	56·7 „ „ 43·3 „ „
7	15·3	25 „ „ 12's „	61·1 „ „ 38·9 „ „
8	11·9	20 „ „ 9's „	59·6 „ „ 40·4 „ „
9	10·7	20 „ „ 7's „	53·4 „ „ 46·6 „ „
10	8·5	15 „ „ 6's „	56·7 „ „ 43·3 „ „
11	7·8	15 „ „ 5's „	52·2 „ „ 47·8 „ „

A′—Cotton and Woollen.

No.	Counts of Twist Yarn in Cotton Hanks.	Thread Units.	Filament Percentages.
1	6·6	12's cotton and 48 sks. woollen	54·9 of cotton and 45·1 of wool fibre
2	5·9	10's „ „ 48 „ „	54·4 „ „ 40·6 „ „
3	5·5	10's „ „ 40 „ „	54·9 „ „ 45·1 „ „
4	4·6	8's „ „ 36 „ „	57·8 „ „ 42·2 „ „
5	4·3	8's „ „ 32 „ „	54·9 „ „ 45·1 „ „
6	3·5	6's „ „ 28 „ „	58·7 „ „ 41·3 „ „
7	3·3	6's „ „ 24 „ „	54·9 „ „ 45·1 „ „
8	2·7	5's „ „ 20 „ „	54·9 „ „ 45·1 „ „
9	2·2	4's „ „ 16 „ „	54·9 „ „ 45·1 „ „
10	1·6	3's „ „ 12 „ „	54·9 „ „ 45·1 „ „

B—Worsted and Cotton.

No.	Counts of Twist Yarn in Worsted Hanks.	Thread Units.	Filament Percentages.
1	57·4	100's worsted and 90's cotton	57·4 of wool and 42·6 of cotton fibre
2	54·5	100's „ „ 80's „	54·5 „ „ 45·5 „ „
3	48·0	80's „ „ 80's „	60·0 „ „ 40·0 „ „
4	44·0	80's „ „ 65's „	54·9 „ „ 45·1 „ „
5	40·7	70's „ „ 65's „	58·2 „ „ 41·8 „ „
6	37·5	70's „ „ 54's „	53·6 „ „ 46·4 „ „
7	34·4	60's „ „ 54's „	57·4 „ „ 42·6 „ „
8	32·7	60's „ „ 48's „	54·5 „ „ 45·5 „ „
9	29·5	50's „ „ 48's „	59·0 „ „ 41·0 „ „
10	28·4	50's „ „ 44's „	56·9 „ „ 43·1 „ „
11	24·0	40's „ „ 40's „	60·0 „ „ 40·0 „ „
12	23·0	40's „ „ 36's „	57·4 „ „ 42·6 „ „
13	19·3	30's „ „ 36's „	64·3 „ „ 35·7 „ „
14	18·4	30's „ „ 32's „	61·5 „ „ 38·5 „ „
15	13·5	20's „ „ 28's „	67·7 „ „ 32·3 „ „
16	12·8	20's „ „ 24's „	64·3 „ „ 35·7 „ „

B′—Cotton and Worsted.

No.	Counts of Twist Yarn in Cotton Hanks.	Thread Units.	Filament Percentages.
1	34·3	60's cotton and 120's worsted	57·1 of wool and 42·9 of cotton fibre
2	31·4	55's ,, ,, 110's ,,	57·1 ,, ,, 42·9 ,, ,,
3	29·7	50's ,, ,, 100's ,,	59·4 ,, ,, 40·6 ,, ,,
4	28·5	50's ,, ,, 100's ,,	57·1 ,, ,, 42·9 ,, ,,
5	22·8	40's ,, ,, 80's ,,	57·1 ,, ,, 42·9 ,, ,,
6	21·5	40's ,, ,, 70's ,,	53·8 ,, ,, 46·2 ,, ,,
7	18·2	30's ,, ,, 70's ,,	60·8 ,, ,, 39·2 ,, ,,
8	17·1	30's ,, ,, 60's ,,	57·1 ,, ,, 42·9 ,, ,,
9	13·3	20's ,, ,, 60's ,,	66·6 ,, ,, 33·4 ,, ,,
10	12·5	20's ,, ,, 50's ,,	62·5 ,, ,, 37·5 ,, ,,
11	10·3	15's ,, ,, 50's ,,	69·0 ,, ,, 31·0 ,, ,,
12	9·6	15's ,, ,, 40's ,,	64·0 ,, ,, 36·0 ,, ,,

C—Cotton and Linen.

No.	Counts of Twist Yarn in Cotton Hanks.	Thread Units.	Filament Percentages.
1	58·3	100's cotton and 392's linen	58·3 of cotton and 41·7 of flax fibre
2	54·5	100's ,, ,, 336's ,,	54·5 ,, ,, 45·5 ,, ,,
3	48·0	80's ,, ,, 336's ,,	60's ,, ,, 40·0 ,, ,,
4	44·4	80's ,, ,, 280's ,,	55·5 ,, ,, 44·5 ,, ,,
5	34·0	60's ,, ,, 220's ,,	56·7 ,, ,, 43·3 ,, ,,
6	24·7	40's ,, ,, 180's ,,	61·6 ,, ,, 38·4 ,, ,,

C′—Linen and Cotton.

No.	Counts of Twist Yarn in Linen Leas.	Thread Units.	Filament Percentages.
1	124 4	224's linen and 100's cotton	55·5 of flax and 44·5 of cotton fibre
2	110·2	196's ,, ,, 90's ,,	56·2 ,, ,, 43·8 ,, ,,
3	96·0	168's ,, ,, 80's ,,	57·1 ,, ,, 42·9 ,, ,,
4	81·6	140's ,, ,, 70's ,,	58·3 ,, ,, 41·7 ,, ,,
5	67·2	112's ,, ,, 60's ,,	60·0 ,, ,, 40·0 ,, ,,
6	52·5	84's ,, ,, 50's ,,	62·5 ,, ,, 37·5 ,, ,,

D—Worsted and Silk.

No.	Counts of Twist Yarn in Worsted Hanks.	Thread Units.	Filament Percentages.
1	36·0	2-fold 120's worsted & 60's 2-fd. silk	60·0 of wool and 40·0 of silk fibre
2	32·1	2-fold 100's ,, ,, ,,	64·2 ,, ,, 35·8 ,, ,,
3	27·7	2-fold 80's ,, ,, ,,	69·1 ,, ,, 30·8 ,, ,,
4	64·3	100 worsted and 44 denier silk	64·3 ,, ,, 35·7 ,, ,,
5	55·4	80's ,, ,, ,,	69·2 ,, ,, 30·8 ,, ,,
6	43·5	60's ,, 50 ,,	72·5 ,, ,, 27·5 ,, ,,
7	38·0	50's ,, ,, ,,	76·0 ,, ,, 24·0 ,, ,,

E—Cotton and Silk.

No.	Counts of Twist Yarn in Cotton Hanks.	Thread Units.	Filament Percentages.
1	34·2	2-fold 120's Cotton and 80's 2-fold silk	57·1 of cotton and 42·9 of silk fibre
2	30·7	2-fold 100's „ „ 80's „ „	61·5 „ „ 38·5 „ „
3	24·0	2-fold 80's „ „ 60's „ „	60·0 „ „ 40·0 „ „
4	20·0	2-fold 60's „ „ 60's „ „	66·6 „ „ 33·4 „ „
5	39·7	60's cotton and 45 denier silk	66·1 „ „ 33·9 „ „
6	35.0	50's „ „ 45 „ „	70·1 „ „ „ „
7	29·8	40's „ „ 45 „ „	74·5 „ „ 25·2 „ „

F—Worsted, Cotton and Silk.

No.	Counts of Twist Yarn in Worsted Hanks.	Thread Units.	Filament Percentages.
1	29·0	2/120's worsted, 2/120's cotton, and 100's/2 silk	48·4 of wool, 32·2 of cotton, and 19·4 of silk fibre
2	25·0	2/100's „ 2/100's „ „ 100's/2 „	50·0 „ „ 33·3 „ „ 16·7 „ „
3	20·0	2/80's „ 2/80's „ „ 80's/2 „	50·0 „ „ 33·3 „ „ 16·7 „ „
4	35·5	80's worsted, 80's cotton, and 58 denier silk	4 ·4 „ „ 29·6 „ „ 26·0 „ „
5	28·9	60's „ 70's „ „ 66 „ „	48·3 „ „ 27·6 „ „ 24·1 „ „
6	24·6	50's „ 60's „ „ 75 „ „	49·3 „ „ 27·4 „ „ 23·3 „ „

18. *Factors Controlling Filament Percentages and Yarn Counts.*—Reference will be made to the yarns in this Table in treating of the many descriptions of union cloth fabrication, but it should be observed that the thickness—yards per lb.—of the twist is, in all instances, governed by the thread units folded together in its construction ; and that such counts are only restricted by the spinning limit in each system of yarn preparation comprised. In woollen, the counts of the unit threads may range from approximately a fraction of a skein to 48 or 50 yards per dram ; in worsted from 1's to 120's ; in cotton from 1's to 160's ; in linen from 30's to 672's ; in silk from 530 to 15 denier ; and from 10's to 180's in spun silk.

Normally, the filament percentages, in the twist, are fixed by the counts of the unit threads, but their respective lengths per yard of the compound yarn are also a modifying element. Tensioning the threads differently in the twisting operation, as well as their relative thicknesses, affects their respective measurements in a given length of twist yarn, and these features need to be taken into account in calculating the filament ratios as factors in the counts of the unit thread formed.

19. *Union Yarns and Quality of Manufactured Product.*—Ordinarily the size of the compound or twisted thread defines or limits its textural utility. The higher the counts and the thinner the grades of woven manufacture for which the yarn is suitable, and *vice versâ;* the medium counts being employed in the production of medium-weight cloths, and the lower counts in the production of heavy goods. Another feature is that the twist yarn is invariably distinguished, in structural character, by the fibrous material used in a plus quantity, causing this filament to give tone and quality to the textiles in which the yarn is used. Hence with union twists forming the warp, weft, or both warp and weft of the texture, they yield the following varieties of woven fabrics—

Series					
A —Woollen and Cotton Union:	with	Wool	quality and character		predominant.
A′—Cotton and Woollen Union:	,,	Cotton	,,	,,	,,
B —Worsted and Cotton Union:	,,	Worsted	,,	,,	,,
B′—Cotton and Worsted Union:	,,	Cotton	,,	,,	,,
C —Cotton and Linen Union:	,,	Cotton	,,	,,	,,
C′—Linen and Cotton Union:	,,	Linen	,,	,,	,,
D —Worsted and Silk Union:	,,	Worsted	,,	,,	,,
E —Cotton and Silk Union:	,,	Cotton	,,	,,	,,
F —Worsted, Cotton and Silk Union:	,,	Worsted	,,	,,	,,

The extent to which certain threads in the twist yarns, and the fibres of which they consist, particularize the fabric manufacture, is largely dependent on the proportionate part they constitute of the material in the woven structure. But, as will be shown, the specific value of the fibrous properties of the yarn is changeable by the methods of weaving and of warp and weft setting, and by the dyeing and finishing practice.

20. *Loom-made Unions.*—These are union manufactures made in the loom by combining, in the warping and shuttling, two or more qualities of yarn spun from dissimilar classes of fibre. They typify the third (Paragraph 1) general scheme of union-cloth fabrication, in which the admixture of the filament units takes place in the weaving process. The yarns are individually composed of cotton, flax, wool, silk, etc., so that it is only by interlacing one sort of thread with another that an assortment of fibrous materials in the manufactured product is obtainable. As now understood, the three principles of filament combination—bi-fibred yarn spinning, union-yarn twisting, and union-fabric weaving—may be devised to produce identical percentages of material composition, but they clearly differ from each other in the textural effects and qualities they yield. In comparing the first and second principles, it was explained how the fibrous ingredients were more fully intermingled, and worked, into a composite class of material in the spinning of a bi-fibred yarn than in the production of a union-twist yarn. This contrast in the admixture of the dissimilar qualities of fibre is further enforced when the woven union-fabric is considered. With each kind of spun yarn forming a part of the warp and

weft of the texture, separately intersected, the ratio of the fibrous elements may be likewise varied, when each species of fibre obtains in the fabric as a distinctive variety of thread

21. *Textural Methods of Combining Yarns Spun of Different Materials.*—The practices of combination include on this principle, (*a*) the use of one description of yarn for warp and a second description of yarn for weft; (*b*) the use of two or several sorts of yarn in the warp, crossed with similar or different sorts of weft yarn; (*c*) the application of yarns of distinct fibrous composition to sectional parts of the warp or weft, as in striped and checked patterns, with the ground portions of the fabric woven in yarns of another quality; and (*d*) the development of spotted, figured and design details in yarns of special counts, and varieties of fibre, from the yarns used in the ground warp and weft.

22. *Comparison of Folded-Yarn and Woven Unions.*—The most effective admixture of the materials practicable by these methods of looming is comprised in (*b*), and consists in arranging the yarn types in alternate order. Assuming, for example, cotton and woollen threads to be selected, they would be grouped in the warping and in the shuttling 1 and 1; and, if the fabric should be plain woven, in the piece the cotton warp ends would be intersected with woollen picks, and the woollen warp ends with cotton picks. Thus intercrossed the yarns produce in the texture a certain filament coherency, the cotton and wool fibre being symmetrically distributed through the structure of the cloth. But the filament assortment and consistency so acquired are neither as definite nor diversified in quality as result in twisting woollen and cotton yarns into one and the same folded thread. In the twisting process the fibres in the cotton traverse, and, in a measure, wrap with the fibres in the woollen; and the respective threads intertwine in regular, compact sequence with each other for the formation of the compound, union yarn. While, therefore, the admixture of the materials is less efficient as regards the blending of filament with filament in the union fabric than in

the union twist thread, and in the latter than in the bi-fibred spun thread; yet it is qualitatively, and in evenness of distribution, satisfactory and complete. Moreover, it will be seen, when the subject is more fully analysed and illustrated, that a degree of fibre intermingling, and also of fibre cohesiveness, may be induced in some grades of union fabrics, in piece scouring, dyeing, milling, and raising.

23. *Utility of Cotton as Warp Yarn in Union Manufactures.*—Cotton is extensively selected as the warp yarn in the looming of the union piece goods covered in the first method of fabrication. Being spun into thick or fine counts, and into soft or firm threads, it is equally adapted for combination with woollen, worsted, alpaca, mohair, linen and silk yarns. Homogeneity and smoothness of structure and weavable propensities render cotton yarns specially appropriate for the warp or chain of union manufactures. Though not of the elastic standard of worsted, the cotton thread permits of high-speed weaving, and also of the qualities of the weft—wool, flax or silk—being clearly distinguished in the fabric. Or, should the textural build involve the warp yarn being a distinctive element, cotton may be thus used.

The spun character of the thread is modified to agree with its functions in the manufactured goods. For combining with the thicker classes of woollen weft, low counts of cotton, preferably loosely twisted, are applied, providing for the equalization in the cloth of the wool and cotton characteristics. In other types of woollen unions, cotton yarns are employed for intersecting purposes purely, or for binding the layers of woollen weft, making the face and back of the fabric, one to the other. Here the cotton warp is effective in building the cloth, but non-evident in the surface features. With worsted—Botany or Cross-bred—it is utilized as a single or as a two-fold warp yarn, the former being selected when the wool and cotton fibres are designed to result in one mixed quality of product, and the latter when the cotton and woollen or worsted threads are intended to develop specific qualities and effects in the

texture. These distinctive yarn properties make cotton threads applicable to the ground, centre, or stitching warp, in the construction of compound cloths—plain or decorative—in which silk, worsted and other wefts are combined. In addition, cotton-warp yarns are particularly suitable for, and used largely in, the manufacture of linen and ramie unions, or of woven unions consisting of two varieties of vegetable fibre. When the commingling of the different filaments, as a resultant of the combination of different kinds of yarn, is sought in the production of these goods, the counts and turns per inch of the linen and cotton should be approximately the same—these conditions being favourable to fibrous unity and cohesion in the processes of piece bleaching and dressing. Cotton, in such unions, imparts flexibility to the fabric, but the manufactures lack the textural clearness and purity of colour observed in textures composed of linen warp and weft.

24. *Varieties of Woollen and Worsted Weft Yarns.*—The weft yarns spun from wool, wool substitutes, alpaca, mohair, Vicuna, and camel's hair, and applied in the weaving of cotton-warp unions, are more diversified in quality, and in structure, than the weft yarns spun from flax, ramie, silk, etc. The carded yarns are made of wool, mungo, shoddy, wool and mungo, wool and shoddy, wool and extract fibre, and wool and noils ; and the combed yarns of short (but evenly grown) medium and long-stapled wool, mohair, alpaca, cashmere, etc. Carded yarn is used as weft in the manufacture of unions ranging from the thin flannel to the thick, heavy blanket or rug ; and in quality of handle from the soft " lambskin " to the firm-woven, well-milled, and pile or nap-finished " beaver," " president " or " pilot." Combed yarn is similarly varied in textural application. Worsted-and-cotton unions include textures of the fine, delicate structure of the *mousseline de laine* and cashmere, of the lustrous nature of the alpaca or mohair dress stuff, of the wearing strength of the crossbred serge, and of the smartness of surface of the fine Botany

suiting or coating. Such types are suggestive of the technical field for investigation and experiment, which widens with the pattern schemes and principles of cloth construction available, and with the combination of such weft yarns with those made of other classes of fibre.

CHAPTER II

COLOURIZATION

25.—Manufacturing Elements and Colour Quality. 26.—Tinting Value of Textile Fibres. 27.—Yarn Structure a Colour Modifier. 28.—Thread Consistency and Shade Contrasts. 29.—Tone Differentiations and Fabric Build. 30.—Yarn Assortment and Textural Features. 31.—Finishing Methods and Colour Tone. 32.—Colour Technology —Bi-fibred Manufactures. 33.—Conditions in which Textile Materials are Dyed. 34.—Union Specimens—Piece-dyed. 35.—Colourization of Spun and Woven Products. 36.—Tinted Folded Yarn—Hank-dyed. 37.—Union Figured Specimen in Two Shades—Piece-dyed. 38.—Yarn Composition for Mixture-shade Dyeing. 39.—Filament Blend—A basic Factor. 40.—Effects of Carded and Combed Yarns in moderating Mixture-shade Quality. 41.—Schemes of Manufacture and Mixture-shade Variation. 42.—Pattern Elements due to Spun Yarns differing in Structure. 43.—Principles in Mixture-shade Production. 44.—Union Fabrication and Piece-dyeing.

25. *Manufacturing Elements and Colour Quality.*—Colour tone and quality, in a textile manufacture, are affected by (*a*) the physical structure and chemical composition of the fibrous material or materials selected ; (*b*) the yarn construction; (*c*) the build or make of the fabric ; and (*d*) the method or practice of finishing. These technicalities have each a specific and modifying influence on the behaviour of the woven product in the dyeing process.

26. *Tinting Value of Textile Fibres.*—To consider, first, the filament properties : each class of fibre when dyed in the natural but " clean," and in the prepared or artificial state, exhibits a distinctive colourization value. Cotton assumes, in the tinting process, a comparatively dull, flat tone ; wool, a full, soft, saturated hue ; flax and rhea an intermediate quality between the cotton and the wool ; alpaca, mohair or cashmere varying degrees of brightness ; and silk a superlative colour richness. Purity in the shade and evenness in the formation of the original fibre, of whatever species, are determinate

factors as to the nature of the dyed colour. Egyptian cotton, showing the same chemical analysis as East Indian cotton, yields in the dyeing treatment a fresher tinted property than the latter. Wools of the Lincoln class possess, in the dyed condition, a higher lustre than fine merino wools, but merino deeper and softer tinted features than the Lincoln ; or, compared with Southdown, of a corresponding fineness of fibre but of a less equalized serrated surface, the merino presents the brighter and fuller colour toning.

In view of these relative tinted values, producible in the use of the several groups of vegetable and animal fibres for manufacturing purposes, the problem of filament admixture is linked with that of the colour quality obtainable in the dyed and finished fabric. Two pieces, one a solid and the second a union worsted, made of identical yarn counts and by identical methods in weaving, would develop different dyeing propensities. Though in the treatment of the union piece the cotton and wool fibres should, as far as practicable, be matched in shade, the colour tone of the cloth would suffer in depth and fullness as compared with that of the pure worsted or all-wool texture, with the higher percentage of cotton utilized in its construction. This element—the colourable standard and attributes of the various textile materials—enters into the fabrication of all grades and classes of dyed union goods.

27. *Yarn Structure a Colour Modifier.*—Considering the yarn structure, this exercises a modifying effect on the colourization of the woven product. The system of intermingling, grouping, arranging and alignment of the fibres in the spinning processes, determines the type of thread acquired, whether smooth or rough in structure, that is, receptive or otherwise, of the true-tinted value of the fibrous materials combined. The more level the thread, the greater the degree of filament parallelization attained in its production, the smoother the surface, and the brighter the colour resultant. And, similarly, the rougher the yarn, the more crossed and varied in length the fibres of which it is composed,

and the softer and denser the dyed colour. In a particular sense yarn structure, apart from the kind of material used, may be converted into a colourant feature of the woven fabric. To combine, in a striped or checked form, carded and combed yarns, and to dye the cloth a simple shade, is an experiment which clearly illustrates the difference in tinting property of the same class of fibre, when prepared and spun into threads distinct from each other in structural formation. The striped and checked sections, woven in the combed yarn, are fresher in colour than the sections woven in carded yarns, but the latter possess the fuller depth of tone. The tinted qualities, thus developed, are specially applicable to this style of pattern, in which they are competent of being graded, in definition, with the selection of the fibrous materials employed. The wool industry supplies a further example of the colour phenomena described, that observed in woollen and worsted manufactures. Here, with wools of a like category and fineness, the worsted thread structure—in Botany and Crossbred qualities—develops a more lustrous species of colouring than the woollen thread structure, whether Saxony or Cheviot. How far they may be rendered coincident in the two grades of worsted and in the two grades of woollen respectively, is definable by the closeness with which the wools and yarn counts agree. In the coarser classes of Cheviots, a certain percentage of the fibres—the longer and straighter sorts—take a comparatively bright colour, whereas, in the finer classes of Saxonies the tinting is full and mellow but somewhat deficient in bloom. In a like manner, brightness of colour toning characterises the thicker group of crossbred yarns and fabrics, on account of the semi-lustrous property of the wool staples combined; and clearness of toning characterizes the finer group of Botany textures, due to the level alignment of the fibres in the thread formation.

28. *Thread Consistency and Shade Contrasts.*—The turns per inch in the yarn, and the twine direction generated in spinning, being related to the thread structure, are also factors bearing

on the coloured aspect of the cloth. Increasing the amount of twist adds to the firmness and compactness of the yarn, as decreasing it in a given counts tends to produce a loose and pliable form of spun thread. In the dyed piece the quality of each yarn is evident in the colour tone acquired. Arranging hard and soft spun threads in lines in the warp or weft and dyeing the cloth blue, brown, or any ordinary shade, discloses the tinted qualities derivable from the degree of twine as

FIG. 1
FANCY WORSTED
—UNION YARNS

distinct from the colour tone originated by the class of filament used, and the system of yarn preparation practised. As a general condition the firmer the twist, the clearer the colouring, and the looser the twist, the mellower the tinted property of the fabric.

Twine direction, or the angle of fibre movement in the thread, qualifies the tinted result when yarns of "right" and "left" hand twist are grouped together in the weaving operation. The fibres in the respective threads are, in this way, presented to the light in different relations. Their disposition

in the yarn is tantamount in effect to that of combing strands of coloured hair reverse ways, causing each strand to take a darker or lighter shade with its power of reflection.

29. *Tone Differentiations and Fabric Build.*—That fabric structure is capable of varying the colour hue is evident on comparing, for example, textures of the rep or cord type with textures of a twilled construction composed of similar counts and grades of yarn, and dyed by the same procedure. The cloths correspond in shade but differ in tint, the *twilled* being distinctly more even and fresher in tone than the *repped* fabric. These colour differentiations are purely a sequence of the orders of the warp and weft interlacings in the two textures. In one specimen—the rep or rib—the warp yarns appear on the surface, the weft being concealed, and the fabric is lined or ridged transversely. Under the microscope the reps resemble series of well-defined furrows. A woven surface of this description is exactly fitted for the expression of a broken and subdued tone of colour. Regarding the twill, the two sets of yarns—warp and weft—intersect equally, and construct an even, level cloth, adapted to the production of the normal colour quality of the fibre and of the thread structure, and, therefore, obtainable by any standard routine of dyeing.

As will be indicated in many varieties of unions, one yarn, *e.g.*, the weft, is floated largely on the upper side of the texture, and this condition reduces the changes feasible in weave elements. Still, there are textural contrasts formable by the scheme of intersection which give a soft, plain, smooth, or a hard, sinuous, rough surface effect, and these become important modifiers of the coloured nature of the cloth. Further, in other union manufactures, certain yarn structures are applied for specific and definite fabric features and properties, and a plan of interlacing is found to accord with these technicalities. As a rule the evener, smoother and more symmetrical the build of the fabric the richer the colour quality; and, conversely, the more serrated the textural surface, the more subdued and, in

a measure, the more impoverished the coloured tone in a specified class of yarn. From which it is to be understood that, with warp and weft of a standard tinted value, this value may be deteriorated or enhanced by the principles of intertexture applied in the construction of the cloth.

30. *Yarn Assortment and Textural Features.*—This theory operates in another sense. Weave design provides for the full advantage being taken of the superior yarn product in union manufactures. It enables the yarns to be assorted in the formation of the fabric, applying the better variety of yarn to the surface and the lower variety to the central part or under side of the cloth. Thus, in a linen and cotton union, while the linen may be made a distinctive constituent of the texture, the cotton yarn may be partially hidden though an essential element in the woven structure. Or, in the instance of a woollen and cotton union, the weft, consisting of wool fibre, as a consequence of the weave unit, may cover the cotton threads, and form a smooth-surfaced sateen manufacture; or should it be interlaced in some twilled or other simple order with the warp ends, the cotton may be only partially concealed and yet the woollen supply the textural quality, and define the colour tone procurable in piece dyeing.

A

B

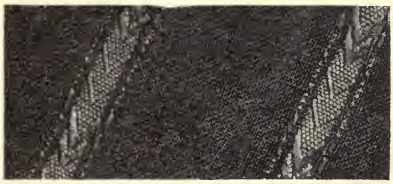


FIG. 2

WORSTED AND ARTIFICIAL SILK PATTERN

31. *Finishing Methods and Colour Tone.*—Concerning finishing practice, it is complex in nature and in the manner in which it may be rendered efficient in emphasizing variations in colour tinting. Inferences may be drawn from dyeing

treatment and results in the " melton," " face," and ordinary types of finish applied to union fabrics. The first is a milled finish, developing a quantity of surface filament, moderated in density with the make of the cloth, the materials of which it consists, and the character of the weft yarn. This filament or " baulk " fibre causes the textural details, formed by the intercrossing of the warp and weft threads, to be almost invisible. Process dyeing on such a cloth has corresponding effects as to colour tone as the dyeing of a piece of carded and felted wool. Depth and quality of colouring ensue as the result of first, felting one shot of weft with another and fibre with fibre ; and, second, of raising the mass of fibre formed on to the face of the fabric, so that it projects, in the form of a short, close nap or pile, from the yarns in the cloth. Perfect evenness of shade is producible, but the original brightness of the wool, as observed when the filaments are lineally arranged, is absent. Finishing practice imparts to the colour, developed in this grade of manufacture, depth and fullness of tone with a minimum degree of lustre and freshness. On the other hand, the combing and dressing of the fibrous nap in the " face " or " doeskin " finish, enhances the bright colouring property of the cloth, which may, if a union production, be of a like structure and felted condition as the melton. But raising action in this finish draws the fibres into a common line, straightening and levelling them in the process, and also inducing that filament compactness and relation typical of the worsted yarn, with the fibres, however, raised from, and uniformly spread on, the textural surface. With the fibres thus laterally exposed to the light, in contrast to the ends of the fibres as in the melton fabric, the lustre value in the wool is enforced, and this imparts bloom and quality of hue to the dyed shades in face-finished cloths.

Finishing methods and procedure are designed to develop and accentuate the colour toning of the general varieties of woven goods. Removing inequalities from the texture as well as cleaning it, the processes improve the feel of the fabric

and add to its brightness and smoothness of surface. In accomplishing this, as in the average worsted or woollen manufacture, they ensure the natural qualities of the fibre being visible in the colour composition of the piece.

32. *Colour Technology—Bi-fibred Manufactures.*—The phenomena and principles examined concern the colourization of the several descriptions of fabrics made in the loom. Colour technology, relative to union manufactures, comprises a number of specialized studies, each susceptive of amplification by experimental research in textile production, and in the use of colouring ingredients. Four leading schemes of investigation are presented, namely, in—

1. The respective stages in manufacturing routine at which dyeing takes place, with the object of obtaining a prescribed quality and grade of tinted product.

2. The diversity and range of dyeing treatment applicable to material blends or mixtures of dissimilar properties, or colouring affinities, when made into yarn or the yarn into a fabric, and including assortments of cotton and wool ; cotton and silk ; cotton, wool and silk ; cotton and ramie ; flax and ramie ; flax, wool and silk, etc. ; and also to the types of yarn structures and the thicknesses and builds of cloth construction.

3. The colouring of special yarn compounds, variously spun and folded or twisted, and for giving in dyeing, whether in the hank form or in the woven condition, a determinable distribution of the tints and shades on the surface of the multi-ply thread.

4. The acquirement, in manufacture, of grades of cloth which, in dyeing and finishing, result in typical styles of pattern due to yarn composition and grouping, and to colour association.

33. *Conditions in which Textile Materials are Dyed.*—Textile materials may be tinted in the " raw " but " cleansed " state, in the slubbing, the combed sliver, the roving, the spun yarn, or in the manufactured texture. In the dyeing of the fibre in these

different conditions—all of which are common in union fabrication—it ought to be feasible to discover colouring agents, and methods of application, which would be less deteriorative of the natural properties of the material than those now applied and practised. For carding efficiency dyeing is not helpful but acts as a deterrent, increasing the work of filament drafting and straightening, and also the staple disintegration. Wool, after dyeing, on account of its matted state, is less fit for carding than wool which has been simply scoured prior to this operation. Advancing to " top " dyeing, it necessitates,

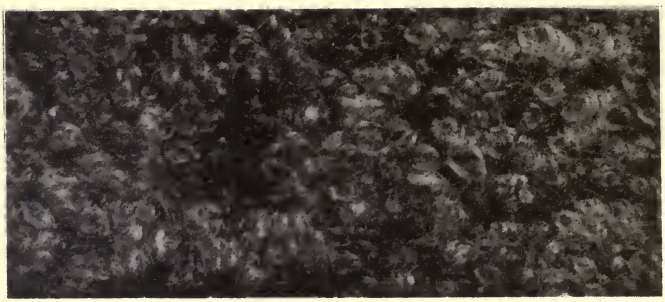


FIG. 3

WOVEN CURL OR ASTRAKHAN—UNION YARN

ordinarily, a re-combing of the slivers to attain a normal degree of evenness and brightness in the thread structure. If piece dyeing should be considered, the process is less detrimental occurring in the final stage of manufacture, but still the qualities of clearness and softness of texture may perceptibly suffer. The problem is one of ensuring accurate and level dyeing with the least disturbance of the filament relations, and yarn and textural features, which the processes and practice of fabrication are formulated to produce.

34. *Union Specimens—Piece-dyed.*—The subject for analysis here is that of the actual colour elements obtainable in the union product—yarn or fabric—as a result of certain schemes of manufacture and systems of dyeing, and will be

explained and elucidated by reference to the following specimens—

Fig. 1. A fancy checked style composed of worsted, cotton, and silk yarns.

Fig. 2, A and B. Cotton and artificial silk textures.

Fig. 3. Curl or Astrakhan fabric.

Fig. 4. Folded or compound yarns.

Fig. 5. Union Figured sample, woven with bi-fibred weft yarns.

The effects in each of these specimens are, as regards tinting, the consequence of combining filaments in the preparation of the yarns of distinctive colouring properties, and of dyeing in the manufactured state. Specimens 1, 2, 3, and 5 are woven in the grey, and dyed in the piece ; and Specimens 4 twisted or folded in the grey, and dyed in the hank.

First in respect to Fig. 1, it is a woven pattern comprising (1) the features due to weave, which are not modifiable by dyeing treatment ; (2) the mingled details in sections A, produced in the folded yarn illustrated at C, Fig. 4, but, in this instance, coloured in the piece ; (3) the intermittent checked effects, B, in white ; and (4) the checkings faintly indicated on lines 1 and 2. Ordinarily, these design elements are acquired thus : The worsted yarns, forming the ground of the texture—dark slate in the original pattern—are " top " dyed. In the second place, the silk threads, giving the check lines, are tinted to the required shade. Third, the twist or folded yarns, composed of cotton and worsted, are produced by dyeing the worsted yarn before folding is accomplished. Here are four separate methods of colourization, each involving a special dye bath, and the attainment, therefore, of the several tints prior to the weaving of the pattern. Utilizing the scheme of " cross-dyeing " the fabric is weavable in the white, and yet all the effects are developable by " process-colouring " in the piece. Thus the texture is in the first place " wool-dyed," yielding the details seen in Part A and in the ground of the cloth, and also the broken check lines—which

remain untinted in the operation—in white mercerized cotton. In the second place, after rinsing thoroughly, the piece is dyed for the artificial silk ingredients ; but providing these were undyed, or that cotton were used in the construction of the compound thread in the place of silk, then the pattern would only require to be wool-dyed. But if the folded yarns should be, as indicated, worsted, cotton and silk, then a second tinting process would be involved. Referring to Fig. 2, it is a representative texture—worsted warp and artificial silk weft—in which the tints are a resultant of, first, wool dyeing in a solution of 0·6 per cent. cyananthrol, 0·04 per cent. sorbine red, and 0·04 per cent. azoflavine ; and second in a solution of 0·4 oxamine light blue, and 0·07 per cent. cotton orange; or some such similar combination of colouring agents. The two shades of curl in the woven Astrakhan specimen, Fig. 3, have also been produced by piece dyeing. The common practice consists in weaving with the desired shades of top-dyed or hank-dyed mohair yarns, so that each special batch of pieces necessitates the use of differently tinted wefts for the curl. Process dyeing offers two alternatives, in both of which the goods are woven in the uncoloured state : (1) Part of the weft yarns—alternate face picks in the loom—are composed of mohair and a percentage of ramie fibre, and the remaining part entirely of mohair or lustre wool as the case may be. Dyeing, for tinting the animal fibres, leaves the rhea filaments unaffected, hence the yarns, of which it is an ingredient, develop a lighter (mixed) tone than the pure mohair yarns, which take a solid shade. (2) A " resist " is applied to one portion of the curl weft threads, enabling piece-dyeing to be done with a two-coloured effect—the unprepared weft taking, in this instance, a different tint from the " resist," " mordanted," or prepared weft yarn.

35. *Colourization of Spun and Woven Products.*—These specimens form suggestive examples of textile colourization as a result of dyeing the woven production made in the grey, but consisting of various classes of fibre, and forms of yarn

structure. They are also illustrative of the styles of manufacture and builds of cloth, which lend themselves to this principle of tinting. More diversified effects than those particularized could readily be originated. If, for instance, the white cotton threads B, in the pattern sketched in Fig. 1, were substituted by twist yarns of the type shown at A, Fig. 4, an additional technical feature would be produced. To the designer, acquainted with the principles of cloth construction, it will be clear that, by following the dyeing methods defined, this type of texture, Fig. 1, could be modified and re-arranged to give other groups of styles besides that exemplified. It serves, however, to suggest the elements underlying the origination, in piece dyeing, of certain features in the fabric which are provided for in the processes of yarn manufacture.

36. *Tinted Folded Yarn—Hank-dyed.*—From the use of twist yarns—A, B, C, Fig. 4—of a definite form and filament admixture, a useful diversity of pattern is also developable in the loom-made product, when this system of colouring is practised. This arises from the latitude afforded in the construction of folded yarns as to the quality, counts, and character of the single threads usable in the twisting frame. The value of yarn variation in acquiring novelty of style in the woven result is well understood, but this knowledge has been derived from experimental studies with coloured materials in several descriptions of yarn, such as "mixtures" of dyed wool and of "multi-fold twists," consisting of threads of which the fibrous units have been tinted either before or in the processes of spinning. Many of the effects, peculiar to these varigated coloured yarns, are producible in the dyed fabric by using union-folded yarns, or compound yarns in which the single threads differentiate in fibre quality and tinting affinities. For instance, the three specimens in Fig. 4 have been dyed in the hank, forming two-shade yarns, but this class of twist is also equally adapted for use in the grey and for dyeing in the woven or knitted texture. Samples A and C are composed of

cotton and woollen, and sample B of ramie and worsted. All union yarns, made of single threads, and spun from animal and vegetable fibre respectively, may be thus utilized in fabrics intended for dyeing in the piece.

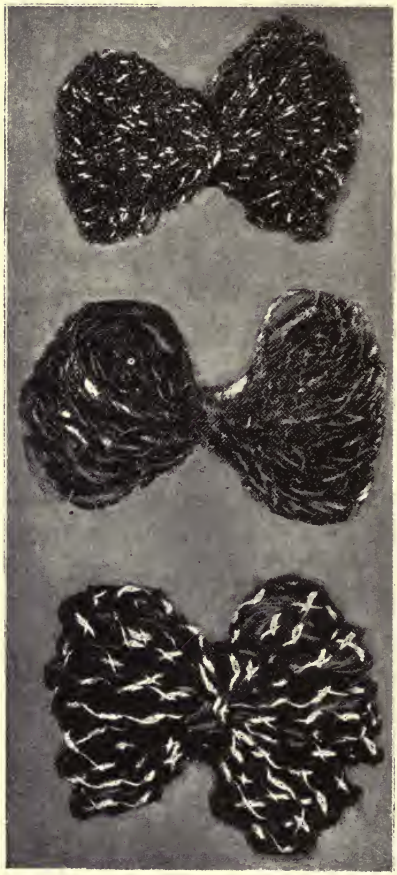


FIG. 4
HANK-DYED FOLDED YARNS

37. *Union Figured Specimen in Two Shades—Piece-dyed.*—The consideration of the specimen in Fig. 5 touches mainly on the second field (Paragraph 32) of investigation. This fabric is two-ply or double in the weft, a species of woven structure which has the advantage of concealing the cotton warp employed, and of presenting a woollen cover on both sides of the cloth. One weft (A = medium shade) contains 80 per cent. of wool and 20 per cent. of cotton fibre, and the other "vigogne" weft (B = lighter shade) 60 per cent. of wool and 30 per cent. of cotton. By dyeing the wool constituents a dark tone, weft A is made to develop a deeper intermingled shade than weft B. As the former, in weaving, makes the ground and the latter the figure, the pattern emphasized by the dyeing process is that illustrated. The reverse surface, in which the wefts A and B interchange positions—A inter-weaving in the formation of the figure and B in the

FIG. 5

FIG. 5A

FIGURED UNION IN TWO SHADES.—PIECE-DYED

composition of the ground—is observed in the section reproduced at Fig. 5A.

The technicalities of the subject are part of the art of blending analysed in Paragraphs 3 and 7. But the problem is now that of the production of bi-fibred yarns which, when dyed, either in the yarn or in the cloth, will result in mixture shades, or in shades consisting of at least two tinted units. The usual method is to combine the relative proportions of the variously-coloured wools in the processes of yarn preparation. To obtain, for example, a grey mixture yarn, the calculated percentages of black and white wool would be carded together forming one " lot," or, to spin a grey worsted yarn, the requisite quantities of dyed (black) and undyed (white) " tops " would be amalgamated in the drawing operations.

38. *Yarn Composition for Mixture-shade Dying.* — These define other principles of mixture-shade origination from the principles of work now comprised, and which supply a product consistent with " mixture-shade dyeing." The former results are the incidence of the admixture in yarn making of *tinted* fibres in fixed ratios. The latter are the incidence of blending—also in yarn construction—in prescribed ratios of *untinted* materials but disagreeing in chemical and physical properties, and of dyeing in the spun yarn or in the manufactured fabric. Colourization takes place in one instance with the filaments in the raw but clean state, and in the other in the prepared, woven or knitted product. The commingling of the tinted fibrous units results in a mixture shade or colour both in the yarn and in the texture ; the commingling of animal and vegetable fibres results in a union yarn or fabric, but in the natural colour of the varieties of material combined. Dyeing procedure develops the mixture effect or tinted *mélange*, imparting to each sort of fibre in the thread or cloth its respective colour value.

39. *Filament Blend—A basic Factor.*—Fibrous composition, that is, " material-blend," is, therefore, of primary importance. It constitutes the basis—the theoretical and practical

preparation—of the mixture shade producible in the manufactured article by dyeing in one or more processes. As such, it commands the following groups of study and technical research—

A. The colour attributes or tinted value, under varied conditions of manufacture, of the different classes and qualities of textile fibre.

B. The influence and effect of dyeing practice on each variety of filament when in the composite form of a spun thread or of a woven, knitted or felted texture, comprising (1) the tone of mixture shade resultant in single-bath dyeing, colouring one of the two or several of the materials in the "union" product; (2) the nature of the tints obtainable on each material in the yarn or piece in the substantive or single-process dyeing of "union" manufactures; and (3) the analogous or contrasting colour tones acquired by dyeing each sort of fibre, in the prepared material, independently, and in successive dyeing operations.

C. The quality or tone of mixture-shade gradation feasible by dyeing methods, as a consequence of modifying the relative percentages of animal, vegetable and other fibres in the construction of the yarn and fabric, including the determination of the depth, or tone, of the shade by adjusting the proportionate ingredients of the different materials forming the blend in the carding or drawing practice.

D. The production of definite grades and varieties of textile fabrics by the employment of accurate ratios of the kinds of fibre combined. This technicality is largely one of manufacturing science, concerning the making of a serviceable yarn and sound texture, but it limits, in some degree, the mixture-colour range, in piece-dyeing, as governed by the mathematical proportions of assorted materials in the blend. The whole is circumscribed by practical or productive considerations, such as the style, structure, and commercial nature of the goods intended.

The tinting problem, which permeates each of the sources

of shade origination defined, intimately concerns the chemistry of dyeing. The manufacture of a product in absolute conformity with a recognized standard of colourization, as a sequence of dyeing, is the sphere of the textile technologist.

40. *Effects of Carded and Combed Yarns in moderating Mixture-shade Quality.*—Primarily, the features in the development of dyed-mixture shades and in the methods of their application will be examined. It is now understood that all such mixtures are a result of combining, in definite proportions, filament varieties ; but the influence of yarn structure on the quality of the mixed shade produced remains to be particularized. Assuming the ingredients to be wool and cotton, a vigogne yarn is obtained by blending the materials in the carding operation, and a bi-fibred worsted yarn by blending the combed slivers in the processes of drawing. These differences, in detail of thread construction, have to be recognized as having an effect on the colour tone of the dyed *mélange* shade. All other technicalities being the same, the mixture tints in fabrics consisting of union combed yarns, for the reasons stated in Paragraph 27, are clearer in quality than in fabrics made of union carded yarns. This tinted distinctiveness, in the dyeing of these typical union thread structures, plainly arises from the greater uniformity of line observed, in the grouping of the fibres, in the worsted as compared with their arrangement and disposition in the woollen yarn. Thread formation is not, however, in such instances, an elemental but a subsidiary factor. It does not qualify the filament composition of the mixture shade, but needs to be taken into account as a modifier of the degree of colour freshness attainable in yarn or piece dyeing. In this sense, it corresponds with other technicalities in manufacture, as, for example, the build of the fabric, felting, raising and finishing work, which have been shown to exert a modifying influence on the attributes of textural toning.

41. *Schemes of Manufacture and Mixture-shade Variation.*—Let the points be illustrated, taking a flannel costume fabric

in very dark grey, dark grey, and medium grey shades. Three schemes of manufacture may be dissected, each of which, owing to the yarn structures combined, develops distinctive properties in the dyeing processes. They comprise—

(1) To give a very dark grey shade.—*Warp :* Union worsted yarn, composed of 90 per cent. of wool and 10 per cent. of cotton. *Weft :* Vigogne or carded union yarn, also composed of 90 per cent. of wool and 10 per cent. of cotton fibre.

(2) To give a dark grey shade.—*Warp :* Union worsted, composed of 75 per cent. of wool and 25 per cent. of cotton. *Weft :* Same as warp.

(3) To give a medium grey shade.—*Warp* and *Weft :* Carded or vigogne yarns, composed of 60 per cent. of wool and 40 per cent. of cotton.

By piece dyeing and colouring the wool ingredients only, the quantitative ratios of cotton and wool fibre in the yarns determine the depth of the mixture shade—very dark, dark or medium grey. The element now for consideration is the tone of colour realized in each scheme of warping and wefting by the yarn structure. From the explanations given, it will be apparent that this will vary with the percentages of worsted and woollen union yarn selected. In the first arrangement, combed yarns are used in the warp and carded yarns in the weft ; but, in the second and in the third arrangements, combed and carded yarns respectively form both the warping and wefting of the fabric. If the three schemes were applied to the production of either one *mélange* or the other, they would differ in colour toning. The discrepancy, in the aggregate blend of cotton and wool in the several shades, does not enter into the difference in colour product as arising from the yarn formation. It affects, as is evident from the colourization value of each fibre, the freshness of the tinted manufacture, but not the colour quality as defined and restricted by the mathematical order of the filaments in the thread structure. Hence, in the examples, the mixture shade in scheme (1) would be the clearer, and in scheme (3) the fuller in tone ;

while the tinted character of the shade in scheme (2) would be betwixt the two.

42. *Pattern Elements due to Spun Yarns differing in Structure.*—Appreciating the toning value of the constructive nature of the yarn, apart from its fibrous composition, suggests its utility in manufacturing practice. Being a source of colour differentiation in piece dyeing, it enables certain descriptions of pattern to be woven. Thus, combining, say, sixteen threads of combed bi-fibred yarns with eight threads of bi-fibred carded yarns of a like counts, in the warping and wefting, would produce a species of shot or shaded checking in the dyed piece. These effects are distinctive of yarn structure, and are obtainable in any tinted type or make of cloth.

43. *Principles in Mixture-shade Production.*—It should be made clear that, in all varieties of " mixture-shade " dyeing, the coloured composition developed is due to the wool (or animal) and cotton (or plant) fibres being perfectly intermingled—Paragraphs 4 to 7—in the carding and drawing routine. Each class of filament is thereby equally distributed throughout the whole formation of the thread. It follows that, in colouring the wool, *e.g.*, black, and leaving the cotton uncoloured, a mixture shade results coinciding with the shade derivable from using corresponding percentages of black and white materials, in yarn making, to the percentages of wool and cotton in the woven piece. To vary the quantities of the two sorts of fibre has, therefore, in this method of manufacture and dyeing, a like effect, in the mixture produced, as that of altering the ratios of the two shades of material in blending for ordinary practice.

On economic grounds, and also for productive purposes, the proportionate quantities of the respective fibres are varied, but it will be apparent from this analysis that, so far as the mixture shade is concerned, changes of this nature have, when the wool fibre is dyed, as in the three schemes specified, two standard results : first, with an increase in the wool (black or colour) constituent in the blend, the mixture shade is darkened in

tone ; and, second, with an increase in the cotton (white) constituent, the mixture shade is lightened in tint.

Neutral greys have been purposely chosen for the illustration of this system of mingled colour production. "Fancy" mixtures, composed of simple and derivative hues, are also obtainable. Thus, the wool fibre in the cloth may be dyed green, olive, brown, or any suitable colour, and in dark, medium and light shades. By tinting the cotton, in such instances, the hue of the wool-dyed fibres, a soft or mellow quality of mixture shade is formed. This implies two dyeing processes, one for each class of filament, and that, if the piece should be coloured brown, green, etc., the cotton would be tinted light fawn, pale green, etc. For mixtures, consisting of two contrasting hues, cross-dyeing is practised, giving the wool and the cotton materials, in the texture, in such tones as blue and orange, claret-brown and heliotrope, olive and lavender—the darker or deeper colour being effective on the wool, and the brighter or intenser tone on the cotton.

44. *Union Fabrication and Piece-dyeing.*—Thus far, the manufacturing result attained is an important species of piece-dyed mixture colouring, variable in fibre grouping and in tinted features ; and one adapted to the standard makes of plain, twilled and elemental-weave fabrics, such as costumes, suitings, overcoatings and cloths for domestic application. When this principle of dyeing, and of yarn and fabric manufacture, is applied to figured and decorative textures of which the specimen in Fig. 5 is an example, other groups of technical problems in colour expression, and in textural construction, require to be investigated. The production of the tinted quality is still based on the intermixture of animal and vegetable fibres in yarn spinning ; but it is now essential that the ground and figured portions of the cloth should be woven in different shade tones. This additional element is provided for by combining, in the loom, yarns of dissimilar dyeing properties. Each kind of thread, whether warp or weft, is located, by the structural plan employed, in the fabric ; or the position

and function assigned to it is made to fit with the definition of the ground, and also of the integral parts of the pattern when the piece is dyed. Now it is not suggested that such dyeing may be practised in the way of a substitute for ordinary routine dyeing, or that it affords the gamut of colour treatment concurrent with individual lot dyeing. It has, however, a specific sphere. As a useful and also as an economical system, it is capable of extended development in union textile fabrication.

CHAPTER III

TEXTURAL TONING

45.—Colour Practice and Mixture-shade Dyeing. 46.—Six-shade Toning. 47.—Maintaining a Plus Wool Ingredient. 48.—Tertiary and Secondary Mixture Shades. 49.—A Scale of Eight Tones. 50.—Mixture-shade Scale Extension. 51.—Construction of a 12-Tone Scale. 52.—Colour Unit and Manufacturing Conditions. 53.—Primary Value of Colour Tone and how Determined. 54.—A Constant Factor in Three-tone Mixtures. 55.—Deductions with Examples. 56.—Yarn Distribution and Textural Evenness. 57.—Filament Proportions in the Yarn and Union-fabric Quality. 58.—Emphasizing Textural Details. 59.—Pattern in Bi-fibred Yarn Fabrics. 60.—Correlative Yarn Qualities and Textural Style. 61.—Inversion of Filament Percentages. 62.—Effectiveness of the Scheme in Experimental Range Making and Dyeing Procedure. 63.—Research Issues and Sectional Investigation. 64.—Economy in Bulk Production.

45. *Colour Practice and Mixture-shade Dyeing.*—The technical utility and application of mixture-shade dyeing in the piece, may now be exemplified, as it bears upon the four fundamental aspects of textile colour practice, namely, (*a*) Shade or tone gradation; (*b*) Two-colour mixture effects, composed of a colour and of white or black, or of two distinct tints; (*c*) Style development relating to the accurate delineation of the textural and design features; and (*d*) The production of sample or experimental ranges of patterns, including the dyeing of the fabric (woven in the white or grey) in suitable colours, tones, or tints.

With multi-fibre blending in yarn construction, and the individual affinities for colouring matter of each class of fibre combined, a basis is apparently provided for acquiring, in the natural-coloured spun, woven, or knitted manufacture, diversified tinted shades, as a consequence of the methods of dyeing followed. The textural qualities imposed, by the proportionate quantities in which the several materials are utilized for the production of specified shades in the process of cloth dyeing,

do not, at present, form a subject for analysis. But it will be understood that the fabrics, made for this system of colour treatment, are varied in fibrous composition, and therefore in quality, by each modification in the tinting of the mixture shade obtained. Piece-dyeing *mélange*-shade production, is thus linked with manufacturing and designing problems. Changes in the materials used in yarn spinning, in the selection

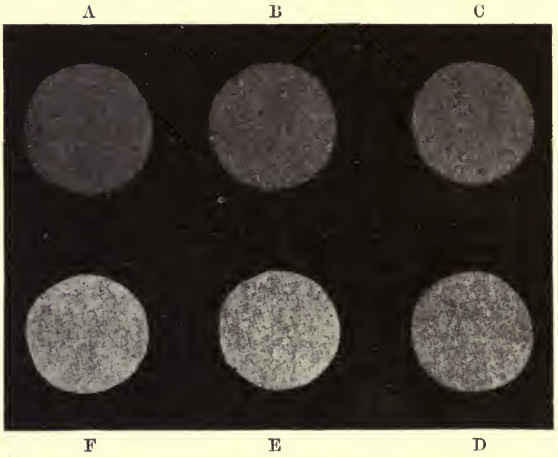


FIG. 6

BI-FIBRED NEUTRAL GREY MIXTURES

and arrangement of the yarns in weaving, and in the construction of the fabric, become, in employing bi-fibred warp and weft threads, instrumental in radically altering the coloured tone of the cloth. Under these conditions, union fabrication, to be efficient in attaining the correct tinted value in the texture, requires to be cognizant of the nature and influence of the filament varieties, and of the groups of processes and technicalities represented in the manufacture of a specific grade of woven product, which, when submitted to a definite dyeing scheme, will yield a certain coloured quality.*

46. *Six-shade Toning.*—As explained, piece-dyeing, for developing mixed colour effects, is an alternative system to dyeing

* See *Colour in Woven Design*, by the same Author and Publishers.

and blending raw materials prior to spinning, but it is not to be regarded as a substitute for the original practice, nor as applicable to mixture-shade origination in the use of materials of corresponding tinting properties. It allows of colour tone gradation in the shades formed, but not to the same extent, or with the same facility, as in the admixture of coloured wools. The quality of the cloth product, and the percentages in which the vegetable, animal and other fibres are combinable, act as restrictive factors. Still, in adapting a basis of standardization in shade gradation, a useful scale of shades in two or three colours may be formulated. In illustration of the principle involved, an example in neutral greys is given in Fig. 6. It contains six mixture-shades graduated from dark to light. The ratios in which the cotton and wool materials have been blended for developing these tones, in "single-bath" (black) dyeing in the piece, are stated in Table IV.

TABLE IV

SHADE GRADATION IN UNION YARNS

Specimens, Fig. 6.	Yarn Composition.	Black-dyed in the Cloth.	White (undyed) in the Yarn and the Cloth.
		Material.	Material.
A	90 % Wool, 10 % Cotton	Wool Fibre	Cotton Fibre
B	80 % „ 20 % „	„ „	„ „
C	60 % „ 40 % „	„ „	„ „
D	40 % Cotton 60 % Wool	Cotton „	Wool „
E	20 % „ 80 % „	„ „	„ „
F	10 % „ 90 % „	„ „	„ „

47. *Maintaining a Plus Wool Ingredient.*—In order that the wool fibre may preponderate in each shade, it will be observed that, in the table of percentages, the cotton and not the wool constituent is dyed in mixtures D, E and F. This serves to equalize the fibrous quality of the cloth in the six shades, but, as the cotton and wool fibre are distinctive from each other in colourization value, the mixtures D, E and F would not, in the black ingredient, be of the same depth of tone as in mixtures A, B and C. For producing the six shades by wool

dyeing, the quantitative factors would need to be changed in D, E and F to—

40 % of wool and 60 % of cotton.
20 ,, ,, 80 ,, ,,
10 ,, ,, 90 ,, ,,

Such a scheme decreases the wool and increases the cotton quantity in the blends with the gradation of the mixtures from the dark to the light shade ; and would, in this instance, cause F to contain 90 per cent. of cotton and 10 per cent. of wool as compared with A containing 90 per cent. of wool and 10 per cent. of cotton fibre. One yarn would be of a woollen and the other of a cotton structure and quality ; whereas, by the method detailed, mixtures A and F, B and E, and C and D, correspond in filament composition, and the yarns resultant are of a woollen or worsted—according to the system of spinning adopted—consistency and nature.

48. *Tertiary and Secondary Mixture Shades.*—Intermediate shades, differentiating in tone and tint from B and C, and D and E, are producible by blending, say, 70 per cent. of wool and 30 per cent. of cotton (wool dyed), and 25 per cent. of cotton with 75 per cent. of wool (cotton dyed). Obviously, in forming such mixture tones, any appropriate dark or bright colour may be selected, and take the place of the black ingredient in the example. Using, for illustration, the tertiary and secondary colours, the blends for giving a series of mixture shades and tints would be constituted as stated in Tables V and VI.

TABLE V

TERTIARY MIXTURE SHADES

Tertiary Colour.	Corresponding Mixture in Fig. 6.	Yarn Composition. (Wool to be Dyed in the Piece.)	Corresponding Mixture in Fig. 6.	Yarn Composition. (Cotton to be Dyed in the Piece.)
Russet	A	90% Wool, 10% Cotton	D	40% Cotton, 60% Wool
Olive	B	80% ,, 20% ,,	E	20% ,, 80% ,,
Citron	C	60% ,, 40% ,,	F	10% ,, 90% ,,

TABLE VI

SECONDARY COLOUR MIXTURE TINTS

Secondary Colour.	Corresponding Tone in Fig. 6.	Yarn Composition. (Wool Dyed in the Piece.)	Corresponding Tone in Fig. 6.	Yarn Composition. (Cotton Dyed in the Piece.)
Orange	A	90% Wool, 10% Cotton	D	40% Cotton, 60% Wool
Green	B	80% „ 20% „	E	20% „ 80% „
Purple	C	60% „ 40% „	F	10% „ 90% „

The percentages of russet, olive, and citron would form shades agreeing in tone gradation with the specimens A, B, and C in Fig. 6, and the percentages of orange, green and purple, tints harmonizing in colour toning with the standards D, E and F. The cotton, in the tertiary compounds, might be suitably tinted a similar hue as the tertiary applied, such as rose tint in the russet mixture, pale yellowish green in the olive, and pale greenish yellow in the citron. This practice, as previously defined, is helpful in imparting quality of colour tone when dark shades are selected, but it is not necessarily followed in the formation of the tinted mixtures.

49. *A Scale of Eight Tones.*—Union yarn quality, as shown, controls and limits the scale of shade gradation. For effective pattern development, combined with satisfactory yarn and fabric manufacture, three or four colour tones, in one variety of mixed product, should not as a rule be exceeded. Additional shades and tints are admissible, but imply the use, in the construction of the cloth, of a pure woollen for the former, and of a cotton yarn for the latter. Shade gradation being determined by the fixed proportions of the two classes of filament assorted in the preparation of the yarns, and confining the cotton unit to 40 or 45 per cent. of the blend for a "woollen" or "worsted" union, the shade tones due to this factor, and obtainable in one and the same dyeing process, should, normally, be restricted to the number named. By submitting, however, the materials to special dyeings the scale of shades in any particular mixture may be extended. The

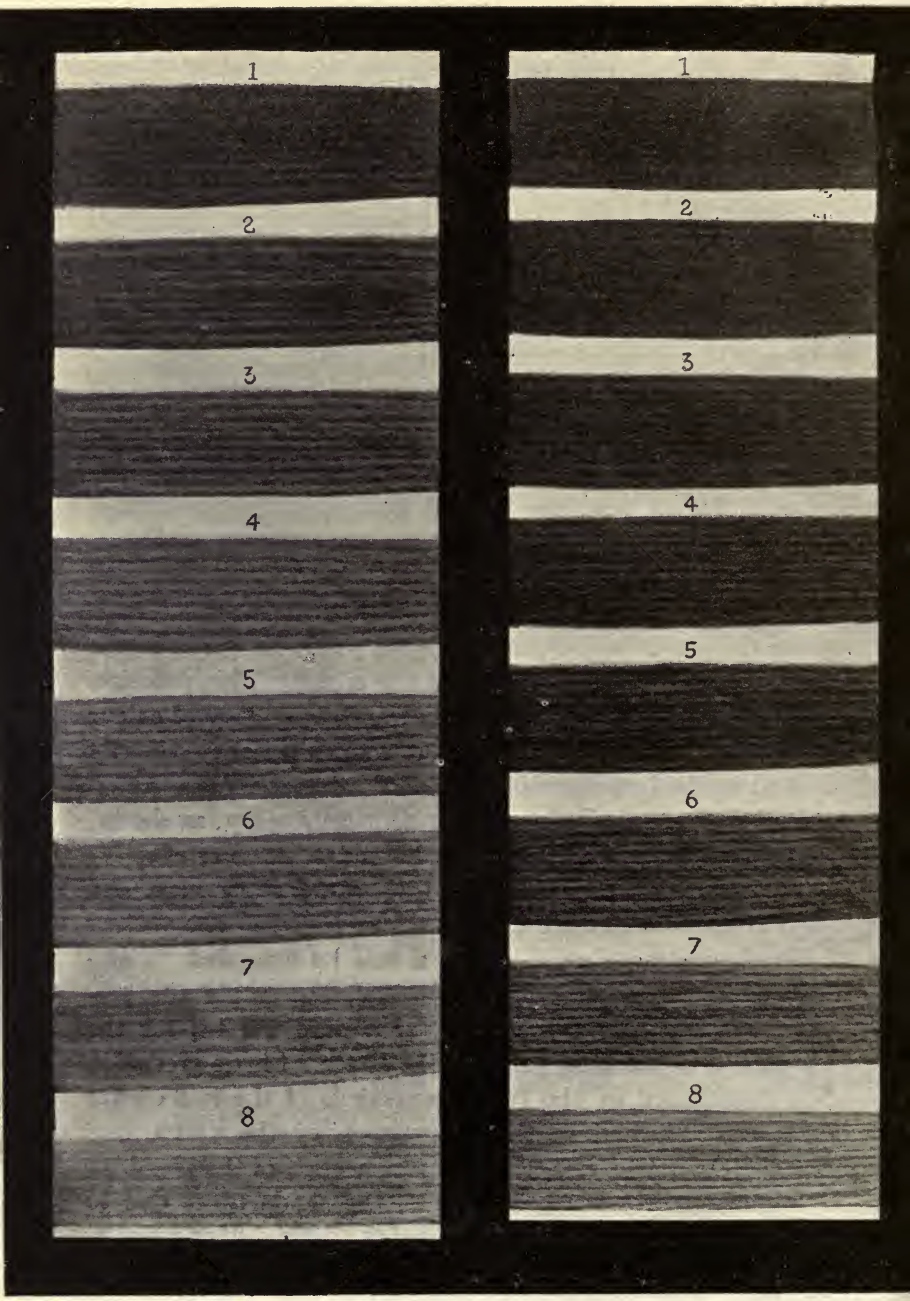


FIG. 7 FIG. 8

EIGHT-TONE SHADE IN BI-FIBRED YARNS. TABLES VII AND VIII

method of doing this is illustrated in Figs. 7 and 8 and in Tables VII and VIII, which contain the data for slate and green mixture shades in eight tones, and acquired in two separate " wool " dyeing processes. Four sets of filament percentages are applied, the cotton being undyed in the slate, and tinted in the green, shades. The colour of the wool for shades 1 to 4, Figs. 7 and 8, is dark slate in Table VII, and dark green in Table VIII, changed to medium slate and medium green for shades 5 to 8. The tone of the medium colour should correspond with that of the mixture-shade 4, in order, when blended in the ratios of 90 : 10, 80 : 20, 70 : 30 and 55 : 45 of wool and cotton respectively, to continue the natural sequence in the gradation of the mixtures 4 and 5, 5 and 6, 6 and 7, and 7 and 8. In the mixtures defined in Table VIII, the cotton as well as the wool is dyed. It is shown uniformly tinted pale green, but, in practice, other tints might be substituted, including pale red, light orange, lavender, etc.

50. *Mixture-shade Scale Extension.*—Scale extension of mixture shades of this class may be carried out on this principle to twelve or more tones, as indicated in Figs. 9 and 10. It takes into consideration the range of yarn assortment, and the selection of colours, for piece dyeing, which will maintain an equalized toning of the shade units from the dark to the light mixture. The yarn assortment, or yarn grading, for producing a definite fibrous quality in the fabric is dealt with later, but, as each bi-fibred thread, according to its filament analysis, has a " tinted " value in the dyeing, it also possesses a " quality " value in cloth. The combination of yarns, in the ordinary systems of warping and wefting, differing largely from each other in material composition, might yield the intended colour tones but prove highly detrimental to balanced textural property. A fundamental idea, therefore, in amplifying the tone scale is the construction of yarns of such filament admixture as to be workable together.

Adopting this basis, the range of wool and cotton

TABLE VII

Eight-tone Bi-fibred Mixture Shade—Wool Dyed

Dyed Colour.	Equivalent Shade Nos. in Fig. 7.	Yarn Composition. (Wool to be dyed in the Piece.)	Dyed Colour.	Equivalent Shade Nos. in Figs. 7.	Yarn Composition. (Wool to be dyed in the Piece.)
Dark Slate	1	90% of Wool, 10% of Cotton	Medium Slate	5	90% of Wool, 10% of Cotton
,,	2	80% ,, 20% ,,	,,	6	80% ,, 20% ,,
,,	3	70% ,, 30% ,,	,,	7	70% ,, 30% ,,
,,	4	55% ,, 45% ,,	,,	8	55% ,, 45% ,,

TABLE VIII

Eight-tone Bi-fibred Mixture Shade—Wool and Cotton Dyed

Dyed Colours.		Equivalent Shade Nos. in Fig. 8.	Yarn Composition. (Independent Piece-dyeing of Wool and Cotton.)	Dyed Colours.		Equivalent Shade Nos. in Fig. 8.	Yarn Composition. (Independent Piece-dyeing of Wool and Cotton.)
Wool Unit.	Cotton Unit.			Wool Unit.	Cotton Unit.		
Dark Green	Tinted Green	1	90% of Wool, 10% of Cotton	Medium Green	Tinted Green	5	90% of Wool, 10% of Cotton
,,	,,	2	80% ,, 20% ,,	,,	,,	6	80% ,, 20% ,,
,,	,,	3	70% ,, 30% ,,	,,	,,	7	70% ,, 30% ,,
,,	,,	4	55% ,, 45% ,,	,,	,,	8	55% ,, 45% ,,

percentages, for making a thread of a wool-like description, should be formulated as specified in Tables VII and VIII. These provide, with dark and medium colours matched in the dyeing, for mixture shades in six and eight tones. Shades intermediate between 1 and 2, 2 and 3, 3 and 4, etc., may be formed by blending the two fibrous units in the proportions of 85 : 15, 75 : 25, and 65 : 35, but the distinctions between the shades in the scale, if thus duplicated, become less accentuated than in those resulting from the percentages tabulated, the toned features of which are exhibited in the photographic reproductions of the yarns in Figs. 9 and 10. The degree of contrast, when such intermediate tones are introduced, is of a similar quality to that observed in the woven specimen given in Fig. 11, the fabric here is strictly a compound union structure, namely a union of cotton and woollen yarns, and a union due to the wefts in Bands B, C, D and F, being composed of cotton and wool fibre. Thus the yarns, for the ground of stripings E, are spun from a fine, short-stapled wool, and for B, C, D, and F from the same sort of wool mixed with cotton in the relative ratios of 90 : 10, 80 : 20, 70 : 30, and 55 : 45. Sections B′ and C′ are chintzed with two wefts—B and D and C and F. The four tones suffer in clearness of definition in the reproduction, but are sufficiently distinct to suggest the series of mixture tones caused, by the differentiations in yarn composition, as a consequence of dyeing the cloth a dark colour. The twist yarns T are made of cotton and do not affect the elements described; and the high percentage of cotton, undyed, in the union yarns F, as compared with the percentages of this fibre in the other union wefts combined, accounts for the light shade developed in this part of the texture.

51. *Construction of a* 12*-Tone Scale.*—Adhering to the scheme of toning laid down, the method of constructing a mixture shade in bi-fibred yarns, and in twelve tones, may be readily explained. From the data specified in Tables IX and X, it will be seen that four dyed colours—dark brown,

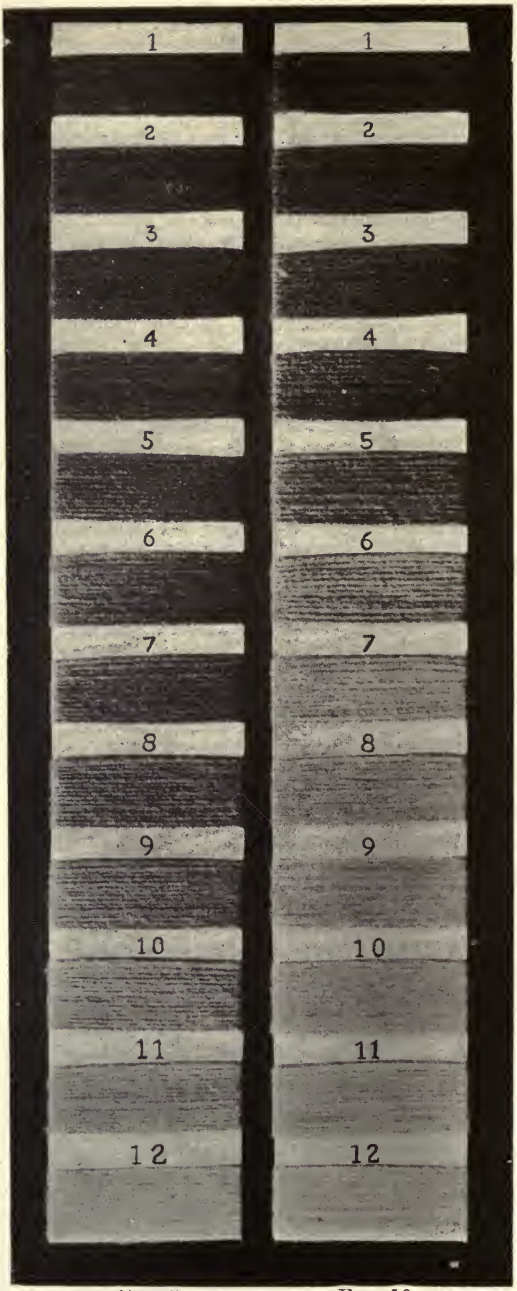


FIG. 9 FIG. 10

BI-FIBRED YARN SPECIMENS—TABLES IX AND X

brown, medium brown and light brown; and blue, medium blue, light and very light blue—are selected for the wool ingredient for the shades in Figs. 9 and 10. For acquiring mixtures 10, 11, and 12 in each series, white takes the place of the tinting colour for the cotton unit. The shade toning is serially graduated by changing the dyed colour for the wool at the fourth, seventh, and tenth shades in the scale. The tone of colour to select is determined by the law of comparison, as in the instance of the medium colour for the eight-tone shades in Figs. 7 and 8; that is, the brown tone for mixture 4 in Table IX is required to match in depth shade 3; the medium brown, for mixture 7, shade 6; and the light brown, for mixture 10, shade 9.

Four groups of shades—1, 2 and 3, 4, 5 and 6, 7, 8 and 9, and 10, 11 and 12—are in this manner formulated. The yarns in each coincide in filament ratios, which makes it feasible to use them in weaving fabrics co-equal in structure and in technical details. The quality of cloth and character of style originated in the first group, or in dark tones, may, by separate dyeing processes as denoted in Tables IX and X, be identically reconstructed in the medium or light tones, and with corresponding shade gradations in the yarns.

A feature to be noted, as illustrating the principle of modifying the scale gradation, is that, in Fig. 10, shade 1 is equivalent in tone to shade 2 in Fig. 9. This is the result of the initial blue or dark colour in Table X being a degree lighter than the initial brown or dark colour in Table IX, and also of the percentage of cotton—tinted unit—being higher in the yarn composition in the blue than in the brown mixtures.

Whichever system of shade toning is practised, that exemplified in Fig. 6 and in Tables IV, V, and VI, or that in Figs. 7 and 8, and 9 and 10, and in Tables VII and VIII, and IX and X, it follows that, with the addition, or reduction, of the ratio of animal or vegetable fibre used in spinning, the quality of the yarn changes in respect to the shade it yields under certain conditions existing in the dyeing of the fabric.

TABLE IX

Twelve-tone Bi-fibred Brown Mixture Shade

Dyed Colours.		Equivalent Shade Nos. in Fig. 9.	Yarn Composition (Independent Piece-dyeing of Cotton and Wool Units).	Dyed Colours.		Equivalent Shade Nos. in Fig. 9.	Yarn Composition (Independent Piece-dyeing of Cotton and Wool Units).
Wool Unit.	Cotton Unit.			Wool Unit.	Cotton Unit.		
Dark Brown	Fawn	1	90% of Wool, 10% of Cotton	Medium Brown	Pale Fawn	7	90% of Wool, 10% of Cotton
,,	,,	2	75% ,, 25% ,,	,,	,,	8	75% ,, 25% ,,
,,	,,	3	60% ,, 40% ,,	,,	,,	9	60% ,, 40% ,,
Brown	,,	4	90% ,, 10% ,,	Light Brown	White	10	90% ,, 10% ,,
,,	,,	5	75% ,, 25% ,,	,,	,,	11	75% ,, 25% ,,
,,	,,	6	60% ,, 40% ,,	,,	,,	12	60% ,, 40% ,,

TABLE X

Twelve-tone Bi-fibred Blue Mixture Shade

Dyed Colours.		Equivalent Shade Nos. in Fig. 10.	Yarn Composition (Independent Piece-dyeing of Cotton and Wool Units).	Dyed Colours.		Equivalent Shade Nos. in Fig. 10.	Yarn Composition (Independent Piece-dyeing of Cotton and Wool Units).
Wool Unit.	Cotton Unit.			Wool Uni .	Cotton Unit.		
Blue	Lavender	1	85% of Wool, 15% of Cotton	Light Blue	Pale Lavender	7	85% of Wool, 15% of Cotton
,,	,,	2	70% ,, 30% ,,	,,	,,	8	70% ,, 30% ,,
,,	,,	3	55% ,, 45% ,,	,,	,,	9	55% ,, 45% ,,
Medium Blue	,,	4	85% ,, 15% ,,	Very Light Blue	White	10	85% ,, 15% ,,
,,	,,	5	70% ,, 30% ,,	,,	,,	11	70% ,, 30% ,,
,,	,,	6	55% ,, 45% ,,	,,	,,	12	55% ,, 45% ,,

52. *Colour Unit and Manufacturing Conditions.*—From this absolute principle, three factors arise for consideration in this class of fabrication: First, the diversity of colouring in the pattern to be produced; second, the system of distributing, in the texture, the several sorts of yarn to give a definite tinted compound of detail effects, and, at the same time, make a cloth of uniform consistency and evenness of structural character; and, third, fabric quality—fineness and softness—as a product of the yarns combined. These technicalities have been touched upon in the explanations made of the schemes of fibrous blending for obtaining graded mixture shades; but it is now a question of the quantitative proportions of the two species of fibre—*e.g.*, wool and cotton—adopted, in yarn construction, to a particular routine of manufacture. When dyed, at one or two processes, the yarns employed in the weaving of the piece are required to develop a specific tone of colour. It is strictly essential that each filament-mixed thread should produce, in the dyeing

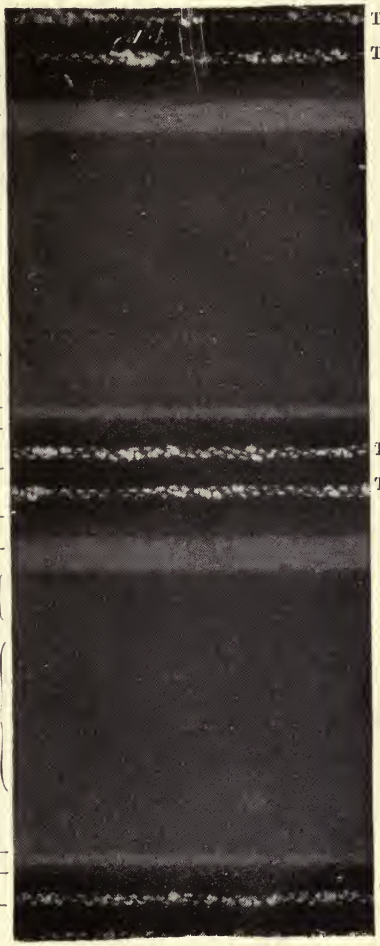


FIG. 11

COTTON-WARP AND BI-FIBRED WOOLLEN WEFT STRIPING

practice, a standard depth and brightness of shade. Unless these elements are to be relied upon, the pattern features and formation, previously fixed in the warping and wefting arrangement by the selection, in a prescribed order, of yarns of a known admixture of wool and cotton—will be destroyed in piece dyeing. But, on the other hand, providing yarns of a correct material composition are available, the pattern features will be precisely delineated in the dyeing operation.

53. *Primary Value of Colour Tone and how Determined.*—Colour tone and expression in the dyed cloth are, therefore, primary and fundamental. In further examining this subject, it will be assumed that two-tone mixture colourings are requisitioned in light, medium and dark shades, and that either the cotton or the wool in the yarns is a colourable unit in the dyeing treatment; then, the proportionate yarn blends, applicable to the development of these tinted results, are, in the first place, decided upon. The following may be taken in illustration of the basis of the practice to be pursued—

I.—*Tinted or Light Mixture Shades*—

A—Very light mixture (cotton dyed) 85 per cent. of wool and 15 per cent. of cotton.

A'—Light mixture (cotton dyed) 70 per cent. of wool and 30 per cent. of cotton.

II.—*Medium Mixture Shades*—

B—Medium-tone mixture (wool dyed) 65 per cent. of wool and 35 per cent. of cotton.

B'—Lighter medium-tone mixture (wool dyed) 50 per cent. of wool and 50 per cent. of cotton.

III.—*Dark Mixture Shades*—

C—Very dark shade (wool dyed) 90 per cent. of wool and 10 per cent. of cotton.

C'—Dark shade (wool dyed) 75 per cent. of wool and 25 per cent. of cotton.

54. *A Constant Factor in Three-tone Mixtures.*—This series of percentages would form, in dyeing the spun and woven materials, a deep colour, two tints in light mixtures—A and

A′—, two intermediate shades, B leaning to the dark and B′ to the light tone, and two dark shades, C′ approaching the

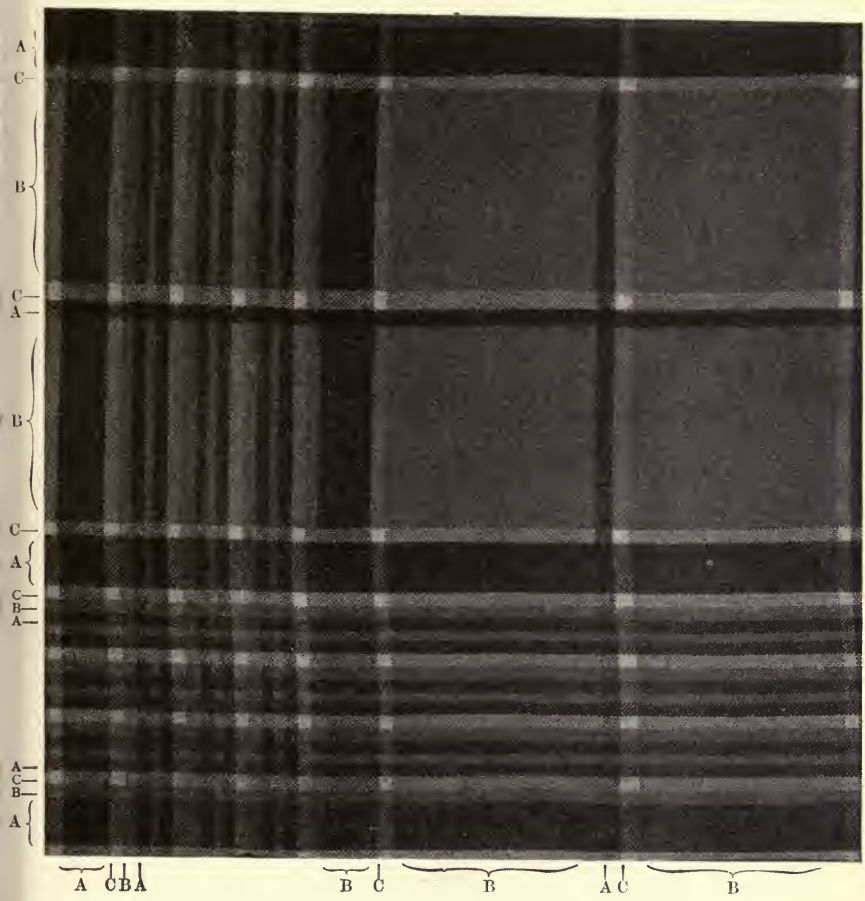


FIG. 12

BLOUSE CHECK. PIECE-DYED

medium shade and C the pure colour matched in the tinting process. The constant factor, in each blend couplet, obtains in the degree of tone contrast betwixt the very light and the light tint; the medium and the lighter medium mixture, and the very dark and the dark shade. Yarn grading as to

filament ingredients, determines this. Hence, whether the woven fabric should be dyed a pale or deep-toned colour, a warm or subdued intermediate shade, or a fresh, intense but dark hue, the scale gradation would be coincident between A and A′, B and B′ and C and C′. Still, it will be understood that the quality and purity of the dyed colour exerts a modifying influence on the apparent contrasts produced. Thus, the dyeing of the mixtures A and A′ pale yellow and purple, or any like contrasting hues, necessarily gives an equivalent tone scale as in the dyeing of pure woollen and cotton textures these respective colours. The distinctions observed, on comparing the tinting of the union and the pure product, are traceable to the percentage of white added to the dyed hue by the non-colouring of the wool fibres in the former or the blended shades. Corresponding differences in colour value are also noticeable in the dyeing of the filament-mixture yarns B, B′, and C, C′ in comparison with all-wool yarns when dyed together, but these differences are now originated by the cotton fibre (undyed) in the threads, which admixes a percentage of white with the colour applied. Taking green to be the dyed shade, the all-wool yarns would be a pure colour, whereas threads B would reduce the colour purity by 35 per cent., and threads C by 10 per cent., resulting in the formation of medium and deep-toned greenish shades.

55. *Deductions with Examples.*—These deductions enable it to be shown how black (wool) dyeing in the piece of the fabric (woven in the grey) in Fig. 12 may, by a suitable arrangement of bi-fibred yarns, be effective in developing the pattern illustrated. It is a union-yarn worsted texture, warped and wefted as follows—

Threads														
A—90 % wool, 10 % cotton =	32	—	6	6	6	6	6	6	32	—	12			
B—50 % „ 50 % „ =	—	6	6	6	6	6	6	6	—	120	—	120		
C—20 % „ 80 % „ =	8	—	—	8	—	8	—	8	8	—	12	8		

After dyeing, sections A of the fabric are, therefore, composed of 90 per cent. of black and 10 per cent. of white fibre, sections

B of equal quantities of black and white, and sections C of 80 per cent. of white and 20 per cent. of black filament, giving dark, intermediate, and light tones respectively. Cotton dyeing the piece would invert the dark and light features in the pattern but would not modify the grey parts, B. Changing the filament ingredients of the yarns to—

A—75% of wool and 25% of cotton
B—60% „ „ 40% „
C—45% „ „ 55% „

and dyeing black, blue, or other desirable colour, would lessen the contrast between the mixture tones. If woven in successive order, and in equal quantities of each yarn, either a shaded stripe or check might be obtained. In the degree with which the colour selected for dyeing is subdued or intensified in hue, the tinted effects in the cloth are softened or sharpened, but the graded toning, due to the filament consistency of the mixtures remains unaltered.

56. *Yarn Distribution and Textural Evenness.*—The method of distributing the different sorts of yarn employed, affects the even, uniform character of the woven product. Differing in fibrous composition, the yarns have clearly dissimilar manufacturing properties. It follows that if they are irregularly grouped, the resultant texture will be varied in quality in its constituent parts. To attempt, by such an arrangement, to produce a consistent grade of fabric would result in considerable sections of threads A, B, and C, proving unsatisfactory. Each of these yarns possesses distinctive shrinkage values, and each forms a special class of manufacture. They might, if combined in limited quantities, weave evenly together providing they were of the same counts and turns per inch, but in scouring and finishing they would be liable to behave differently ; and to give, as a result, an incorrectly balanced texture. Associating with these thread groups, solid worsted or all-wool yarns, would further accentuate the irregularity of textural surface developed. Yet such yarns, when suitably arranged in the warping and wefting, may be

applied, and an even make and type of cloth, as to structure and finishing nature, be acquired. By adhering to the rule of frequently intermingling the several kinds of yarn in

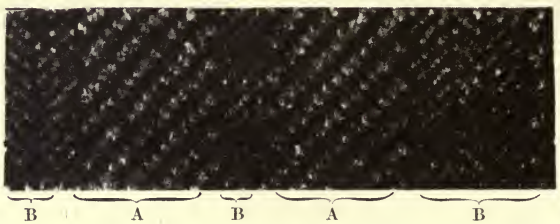


FIG. 13

BI-FIBRED TWEED

systematic order—a practice common in the origination of numerous schemes of textile colouring—the differentiations in the filament properties of the yarns, necessary to develop the shades and tints characteristic of the pattern by piece dyeing, may be accurately adjusted to the technicalities and conditions of the finished cloth.

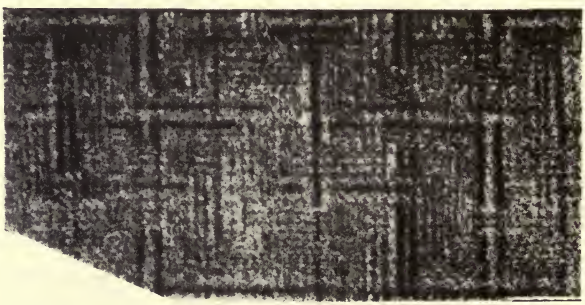


FIG. 14

BI-FIBRED RAISED SAXONY

57. *Filament Proportions in the Yarn and Union-fabric Quality.*—Union-fabric quality is primarily determined by the nature and relative quantities of the materials used in yarn preparation. In changing the percentages of the fibres in the warp and weft, for varying the colour tones of the pattern

in Fig. 12, the fabric quality was also modified, the original yarns giving, approximately, a texture of eight parts of wool and seven parts of cotton, and the substituted yarns a texture of three parts of wool and two parts of cotton fibre. For a like reason, fabrics made of mixture yarns A (Paragraph 53) would be superior to those made of yarns A′, and the latter than those composed of yarns B. The respective wool and cotton values of the yarns are imparted to the woven texture in each plan of combination in the looming and weaving of the piece. With the tendency, in selecting and grouping the threads, to increase the percentage of cotton, the softness of the cloth producible is reduced, but this does not deteriorate the quality of fineness, as derived from the application of fine counts of yarns. On the other hand, with the tendency to diminish the cotton and add to the wool unit in the threads, the fabrics improve in flexibility and suppleness, and in the diversity of finishing work to which they may be successfully submitted.

Quality, in all such union productions, is mainly governed by the shade tone desired in a specific dyeing process, as this fixes the ratios of the two classes of fibre. Thus, to use a higher percentage of wool fibre in the mixture yarns C (Paragraph 53) would raise the textural quality but also give a deeper colour tone ; and, in a like manner, to lower the wool and augment the cotton ingredient—seeing that cotton in this mixture remains untinted in dyeing—would give a lighter tone of colour but lessen the textural quality. These are the two controlling and elemental principles. They render it essential, in this branch of fabrication, to have regard, first, to the dyed colour ascertainable in the yarns, whether wool or cotton dyed ; and, second, the ratio of the two fibres in the whole texture, and their evenness of distribution throughout the whole scheme—the relative proportions of the filaments intermixed being the basis of the actual manufactured product.

58. *Emphasizing Textural Details.*—The definition of pattern by this scheme of colouring, restricted to the use of bi-fibred

yarns, is one that embodies the technique of yarn construction, weaving and manufacture, and of dyeing practice. It is invariably, unless the union yarns are mixed in the looming

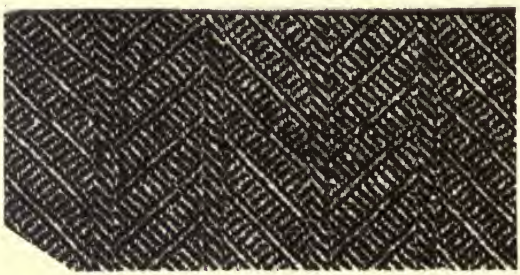


FIG. 15

BI-FIBRED WORSTED

with cotton or woollen yarns, a problem of developing the textural details in mixture tones rather than in pure colour contrasts, such as are acquired in yarns in which the raw material, the " combed top," the " slubbing," or the spun thread is dyed. Yarn grading, with a view of attaining the correct colour value—*i.e.*, tone and depth of shade or freshness of tint—is

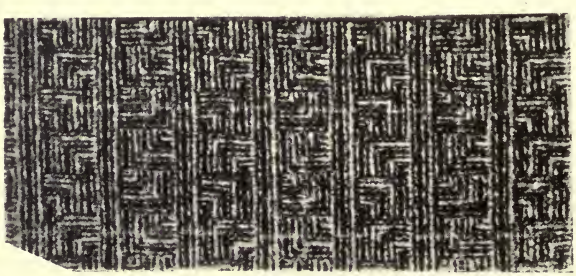


FIG. 16

BI-FIBRED FINE WOOLLEN

all important. It modifies and prescribes the fabric style and design features producible.

59. *Pattern in Bi-fibred Yarn Fabrics.*—The principles of work comprised, in developing the pattern features, will be explained in reference to the bi-fibred yarn textures illustrated in Figs. 13, 14, 15, 16, and 17. The first specimen is

of a tweed character, having two shades of warp crossed with a dark weft. For weaving in the natural colour and for dyeing to any suitable shade, the yarns in stripes A should be spun of 70 per cent. of wool and 30 per cent. of cotton, and the yarns in stripes B of equal portions of the two fibres. The weft may be either a vigogne or a pure woollen yarn. If the former, it should contain from 10 to 15 per cent. of the vegetable filament, but not more if intended for " wool " dyeing, otherwise the tone contrasts in the style would be modified. Introducing cotton into the spinning of the weft yarn, diminishes the clearness of the textural intersections, inasmuch as it makes this a mixture yarn in place of a solid-colour yarn as in the original sample. Fig. 14 is a semi-pile finished cloth in which three qualities of yarn are combined, the black warp and weft threads being all-wool, and the dark and lighter threads admixtures of cotton and wool. Here, to acquire softness of tone, the cotton as well as the wool should be tinted, either before the operations of spinning, or in the piece. Should this not be done, the undyed cotton, in raising, depreciates the quality of the mingled shading, its comparative rawness becoming a detrimental feature of the short nap of filament characteristic of the finished fabric. Both these examples suggest the importance of adjusting the ratio of the materials to the colour tones to be produced by the dyeing process, and also of the relation of the yarn type to the particular effects in the style it is designed to develop and accentuate.

The method of yarn distribution, dealt with in Paragraph 56, in attaining textural evenness and fibrous equality of cloth, enters into the construction of the patterns in Figs. 15 and 16. Yarns of a maximum differentiation in filament composition have been selected, the threads for the dark shade containing 90 parts of wool and 10 parts of cotton, with the percentages inverted for the threads in the light shade. Regarding the bi-fibred worsted texture, Fig. 15, it is arranged end-and-end in the warp, and weavable with a solid worsted or a fine spun

woollen weft. The fabric is built on the warp-twill base, only the warp threads showing as in a cord weave, which allows the picks of weft to pass between the warp ends as they form the face and underside of the texture. In arranging the two sorts of yarn thread-and-thread, and in binding them together with an all-wool weft, their respective fibrous properties are distributed evenly through the fabric structure. Corresponding conditions obtain in the production of the specimen in Fig. 16, but the warp and weft shades are now grouped as below—

2 threads of all-wool yarn = black.
1 thread of bi-fibred yarn (70% of wool and 30% of cotton)=dark grey.
1 „ „ „ (55% „ „ 45% „ =light grey.

The weave, in this instance, is broken warp-face four-end twill, and the piece contracts from 70 in. in the loom to 56 in. in width in the felting process. Seeing that one-half the threads are made of wool, one quarter of 3 parts of cotton and 7 parts of wool, and the remainder of 9 of cotton and 11 of wool fibre, they would, if arranged in groups of 8, 16, etc., and in successive order, produce a cloth varying in shrinkage, and also in wearing value, with the yarn structure of which the several sections were woven. By, however, assorting them as indicated, the inequalities in their material composition are formed into a textural unit of uniform felting property and surface consistency. From this and the preceding example, it is to be observed that, with the yarns disagreeing largely in fibre formation, but in accordance with the tone of shade to be acquired in the dyed piece, the scheme of warping and wefting changes the quality of the fabric, first, as regards its serviceability; and, second, relative to its behaviour in the finishing practice. It is imperative that the threads should be so grouped and intermingled as to render the texture, throughout its construction, of the same filament nature and substance. Moreover, when the warp yarns are so distinctive in character as in Fig. 15, with the object of facilitating accurate and economic piece weaving, it is desirable that they

FIG. 17

MOTOR CLOTH—WOOL AND RAMIE FIBRE YARNS

should be dressed on two chain beams for the proportionate tensioning of the light (excess cotton) and the dark (excess wool) threads, in keeping with their respective tensile standards, and the effects for which they are severally responsible in the fabric.

60. *Correlative Yarn Qualities and Textural Style.*—Yarns more closely approximating each other in fibrous character are applicable to the heavy, two-fold make of cloth in Fig. 17. For the face and backing warps and the face weft, union worsted yarns are useful with union woollen yarn for the backing weft, to produce a texture suitable for raising on the under side. The toned contrasts observed result from the threads being composed of 90 per cent. of wool and 10 per cent. of ramie fibre for the light sections of the pattern, of 60 and 40 per cent. of each filament for the intermediate light shade, and of 75 per cent. and 35 per cent. of each material for the deeper intermediate shade, dyeing the vegetable fibre in the piece a medium colour. The structure of the fabric is further equalized by the light-shade yarn being employed in the formation of the reverse surface. The strength of the tinted toning is susceptible to the quality of the colour matched in the dyeing ; if this should be a dark shade, the contrasts are intensified, but if a soft, secondary shade, as in the specimen, the contrasts are correspondingly subdued, and the checked features become less pronounced.

Sections B and the ground A of Fig. 18 are also woven in bi-fibred worsted but wool dyed—the fibres (wool and ramie) being equally admixed in yarns A and in the ratio of 65 : 45 in yarns B. In addition, threads of worsted and of ramie have been inserted into the warp and weft for the clear delineation of the cord check lines, C. A deeper dye has been chosen for the treatment of the cloth than in the preceding type, hence the more marked distinction in the style of the checkings as compared with Fig. 17. All bi-fibred yarns, however dyed, produce a species of mixture-shade toning, which, as in this example, may be utilized in obtaining strong tinted contrasts

by combining them with yarns spun from vegetable or animal fibre. Either one or the other, varying with the dyeing practice, remains untinted in the piece, while its associate takes a solid colour. In this pattern the worsted yarns in C are tinted, and the ramie yarns are not. Selecting a green dye, the worsted would be tinted this colour, the ramie would continue

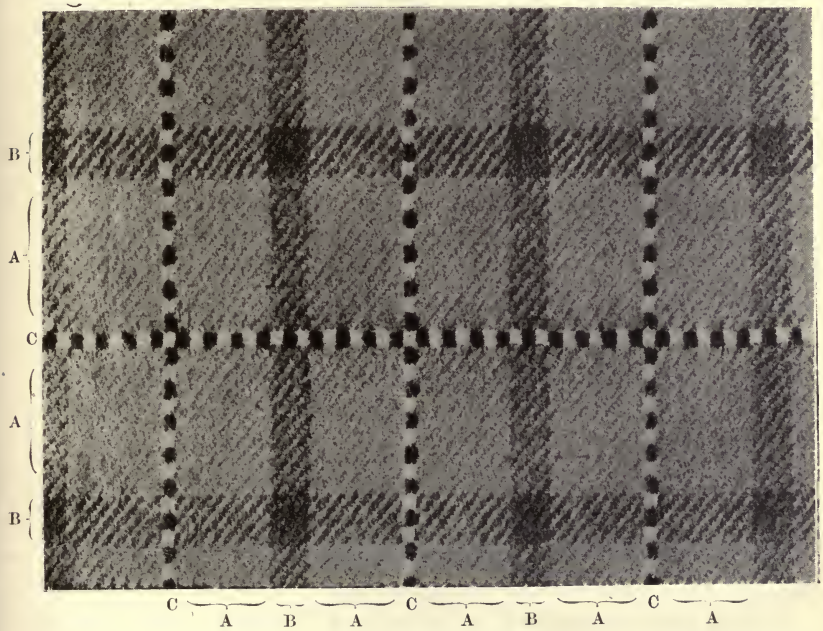


FIG. 18

VESTING—BI-FIBRED YARN STRUCTURE

the natural colour; and threads A take an intermediate, and threads B a darker, mixed greenish-grey tone.

61. *Inversion of Filament Percentages.*—Inverting the proportionate factors of the two kinds of fibre blended in making the yarns, may alter both the scheme of toning and the scheme of the pattern arrangement. Thus, if the wool and ramie filament in the yarns B of the last specimen, were intermingled (B sections) in the ratio of 45 : 65, these elements of the pattern

would be developed in a lighter, instead of in a darker, tone than the ground portions A. Again, by modifying the dyeing practice, tinting the ramie in place of the wool in the process, the textural effects would also be transposed, the ground becoming the deeper, and the checkings the lighter, mixed shade. But this results in a class of manufacture in which the cotton or ramie is the staple material, and this may be effected satisfactorily, and in a pale variety of colouring, by dyeing the animal fibre and increasing the percentages of the vegetable fibre in the yarn spinning operations. Examples of this description are furnished in Figs. 19, 20, and 21. They show the system of constructing cloths of a thin cotton character improved in appearance and handle, and diversified in tinting, by the use of small quantities of wool in combination with the cotton staple. The yarns are, in such specimens, admixtures of 5 : 95 (C′ = light-shade yarn), and of 35 : 65 (C = intermediate-shade yarn), of the two materials. The plan of fabrication differs in the several textures, that for Fig. 19 being a warp twill, providing for sections A being warped one-and-one in yarns C′ and C, and sections B in C′, using yarn C for weft. Specimen 20 is a two-and-two twill structure, with the yarns grouped 6 of C′ and 4 of C. Fig. 21 is warped and woven 2 threads of C′, 2 of C and 2 threads of C′, so that two-thirds of the fabric consist of the yarns formed of 5 per cent. of wool and 95 per cent. of cotton, and one-third of the yarns formed of 35 per cent. of wool and 65 per cent. of cotton ; and Fig. 22 a five-end Venetian cloth, warped 10 threads of C, 4 of C′, 2 of C and 4 of C′, and shuttled in the yarn C. Colouring the wool fibre, in the dyeing of the piece, develops the light mixture tones seen in the features of the patterns, which are, in all instances, prescribed by the system of yarn construction, the looming practice, and the plan of warp and weft interlacing adopted.

62. *Effectiveness of the Scheme in Experimental Range Making and Dyeing Procedure.*—The effectiveness, in experimental range making of this system of fabrication will be

apparent. A style of design having been originated, including a cloth type, the fabric may be dyed in selected colours—light, intermediate or dark tones—and yet only one scheme of production be involved. But the dyeing procedure, on this basis, requires to be duly appreciative of the methods of manufacture, and of the fibrous composition and structure of the yarns employed. The ingenuity of the designer is exercised in the assortment, in the warping and wefting, of the grades of yarn adapted, when tinted, to the correct delineation of the pattern elements; and the technique of the dyer is exercised in the application of colouring matters and processes which will give economic results, and clearly express, in a suitable diversity of tints and tones, the different features in the design. Each technologist acts independently, but both have in view the colour composition of the fabric as the essential to be attained. In the case of the designer, his skill, experimental knowledge, and invention, are evident in the fabric build, and in the distribution in the texture of the yarns of varying colourable qualities, and in strict accord with the form and style of the pattern intended. As to the

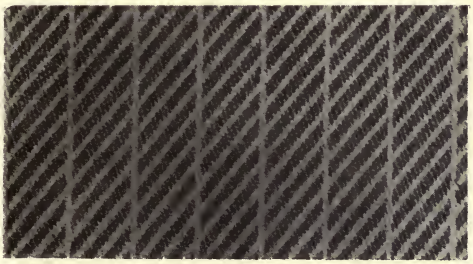


FIG. 19

TWILLED COTTON-AND-WOOL YARN UNION

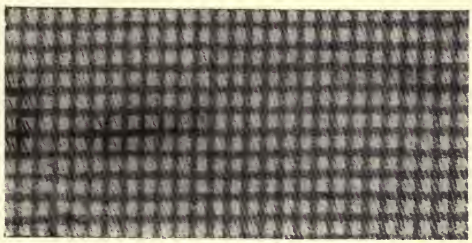


FIG. 20

SMALL CHECKINGS—COTTON-AND-WOOL YARN UNION

dyer, his chemical science and technical faculty are observed in the acquirement of a tint, tone or hue of colour, which, under the gradations to which it is subjective in the different sorts of yarn to which it is applied, will precisely define, and yet suitably modify, the design characteristics in the dyed piece.

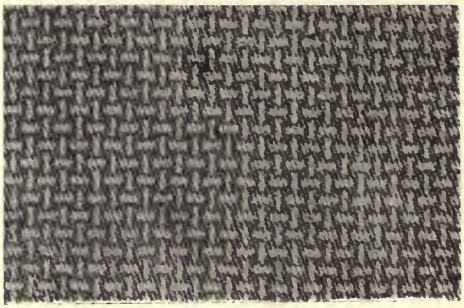


FIG. 21

COTTON-AND-WOOL YARN UNION

63. *Research Issues and Sectional Investigation.*—The whole problem is suggestive of the overlapping of research issues in textile manufacturing. Sectional investigations may be chiefly concerned in amplifying one phase of productive effort, or they may be immediately related to ulterior processes and results. But in this species of technical inquiry, each series of operations, including the determination of the material blend to be utilized, the scheme of yarn preparation, weaving as fixing the thread composition and make of the cloth, dyeing as responsible for the tinted contrasts obtainable in the fabric, and finishing treatment as imparting specific textural qualities and features, form correlative subjects of investigation. Certain factors may appear as minutiae, but in given combinations, and under definite conditions of manufacture, they exert an originative or primary value, inasmuch as they fix the nature of the effects in the finished production. Filament

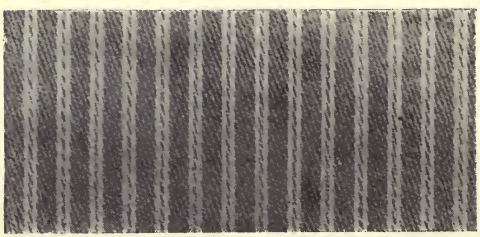


FIG. 22

VENETIAN-TWILL STRIPE

COTTON-AND-WOOL YARN UNION

properties—chemical and physical—yarn consistency, resulting from the system of work followed, and fabric build, necessitating a prescribed arrangement and grouping of the warp and weft threads, all compose technicalities and principia which need to be planned, and adjusted, with a view to the ultimate characteristics and qualities they are competent of yielding, individually and collectively, in the dyeing of the woven goods.

64. *Economy in Bulk Production.*—The technological features dealt with in reference to the origination of coloured styles by yarn structure and dyeing processes, suggest the strata on which new lines of manufacture are capable of being developed. In the first place instead of having, as in ordinary practice, recourse to an extensive assortment of coloured yarns, several varieties of standardized union mixture threads are selected. This, in itself, simplifies the scheme of fabrication. Spinning routine is less complicated, and attention is concentrated on the acquirement of yarn quality in a given counts of thread of a known filament composition. With the elimination of a diversified and heavy stock of "fancy" shades, great economy in bulk production is effected. All goods are made in the grey or natural colour, and a comparatively limited range of warp and weft yarns is requisitioned, and yet the grades of coloured fabrics are not only maintainable, but in some senses extensible. The latter element is rendered practicable by the system of dyeing introduced, enabling each style of pattern, as exemplified, to be acquired in any suitable series of colour tones and tints. Newness of shade in plain, twilled and standard makes of texture, as also in "fancy" cloths, is a fundamental factor in manufacturing activity. Design and textural effects are enhanced in commercial value by colour excellence and freshness; and dyeing technique, in attaining this object in bi-fibred production, becomes an effective source and unit of success in pattern work and style origination.

CHAPTER IV

PATTERN ORIGINATION

65.—Loom-Coloured and Piece-Coloured Design Practice. 66.—Analysis of the Two Systems of Designing. 67.—Dyeing and Intensity of Colour Unit. 68.—Variation of Textural Features 69.—Facilities in Experimental Pattern Production. 70.—Methods of Style Origination. 71.—Diversification of Shade Tones and Experiment in Design. 72.—Examples in Yarn Assortment and Pattern Construction. 73.—Yarn Distribution and Shade Toning of the Cloth. 74.—Effect of Elaborating the Weave Basis, with Specimens. 75.—End-and-End Warping and Compound of Three Weave Types. 76.—Mingled-shade Tones and Pattern Definition. 77.—Application of Nine-tone Scheme. 78.—Indefinite and Decided Contrasts. 79.—Toned and Mezzotint Contrasts. 80.—Accentuated Warp and Weft Contrasts. 81.—Tone Contrasts and Weave Types. 82.—Design Elements and Manufacturing Practice—Illustrated. 83.—Shade Tonation in Striped, Checked, and Figured Styles. 84.—Suitable delineation of Textural Details. 85.—Figured Examples with Shaded Stripes in the Warp.

65. *Loom-Coloured and Piece-Coloured Design Practice.*—As regards weave elements and principles of intertexture,—loom-setting and cloth structure—the system of pattern origination, in bi-fibred yarns, is synonymous with that practised in pattern origination in coloured yarns. Design and style, as a resultant of colour assortment and combination, are obtained in the latter by arranging, classifying, and grouping the tinted yarns in the warp and weft in the weaving of the piece. On the other hand, in the bi-fibred scheme, design and style of a coloured nature, are due to arranging and grouping yarns of different filament consistency either in the warp, weft, or both warp and weft, weaving in the grey, and depending on the dyeing process for the development of the colour toning. In the first instance, the colour effects, contrast and quality, are evident in the loom, being essential features and component parts of the woven product, so that the pattern is in every detail complete, and the prototype of the design as it appears in the finished fabric.

In the piece-dyed manufacture, colour, as a distinctive pattern characteristic, is an invisible effect in the processes of cloth fabrication. Yet it is as much a sequence and product of yarn distinctions, and of yarn applications, as of colour toning in the loom-tinted texture. But it remains a dormant, a concealed factor until dyeing takes place. There is strictly no problematical element, as to the tinted textural results, in either system ; but one result is ordered, fixed and defined in the loom, and the other is ordered in the looming, and developed, fixed and defined in the dyeing of the piece.

FIG. 23

COLOUR SKETCH—BI-FIBRED YARN TEXTURE

66. *Analysis of the Two Systems of Designing.*—To consider the two practices relative to the simple scheme of yarn grouping in Fig. 23, and weavable in the 14-heddle plan shown at Fig. 23A, the order of the yarns in the warping and shuttling is three threads of dark grey, two threads of intermediate, and two threads of light grey. By the ordinary designing method, the yarns would be thus combined in the loom, and would give each line and detail, as seen in the sketch, clearly accentuated in the texture. By the second method, the yarns would be used in the natural colour but consist of the filament ratios specified for the production of the grey mixture shades 1, 2, and 3 in Fig. 6. In weaving with such yarns, there would be no distinctive features observed in the fabric arising from the three types of thread assorted, beyond the fugitive tints applied in the processes of spinning for the accurate differentiation of the yarn qualities. On dyeing the cloth, the pattern

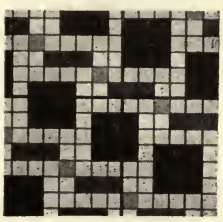


FIG. 23A

elements would be formed and become distinguishable as illustrated.

If the object should be the origination of a style range, comprising six similarly toned patterns, in each of which the design characteristics and shade contrasts were identical, then, by the former practice, this number of ground tones, say, dark grey, brown, blue, green, slate and olive, and all of an equal tone depth, would be selected. Toning shades, corresponding to the medium and lighter grey in Fig. 23 would next be decided upon for the several ground colours, maintaining uniformity of colour contrast, or tone balance, throughout the range. The warpings for the respective patterns would be grouped in successive order in the loom, hence, in the serial matching of each in the shuttling, five out of the six warp colourings would be "cross" wefted, producing, in addition to the six regular pattern types, thirty irregular or "bastard" specimens.

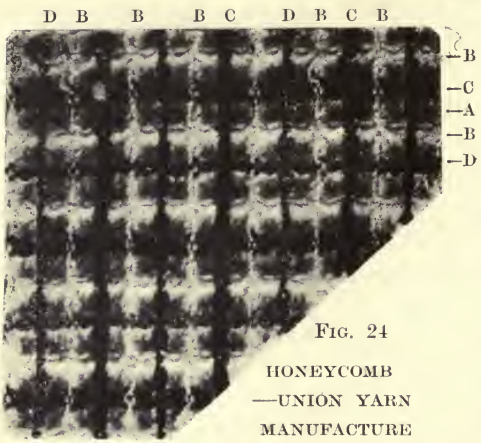


FIG. 24

HONEYCOMB —UNION YARN MANUFACTURE

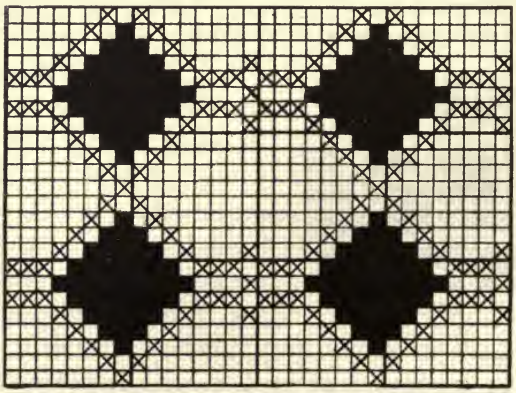


FIG. 25

67. *Dyeing and Intensity of Colour Unit.*—On the second

principle of work, the dyeing of the textural sample, specially prepared, would determine the colour unit—intensity of hue and depth of tone—effective in providing the degree of pattern definition desired. Having ascertained this by experimental dyeings, the colours for the style range would be fixed upon, and lengths of cloth tinted accordingly. Cross-weftings, which are a source of intermingled tinting in the loom system of design, are eliminated from this practice. Variations in pattern style are possible in a given order of warp yarns by changing the order of wefting, but the tone gradations—in one group of mixed shades—are absolutely restricted to the thread qualities employed in the weaving of the fabric. The nature of the limitations imposed, in comparison with the facility for diversified tinting in using coloured yarns, is explainable by reference to the "fancy" honeycomb texture in Fig. 24. This pattern, constructed in the plan given in Fig. 25, is a compound of warp and weft yarns arranged as below—

Yarns			Order of Warping and Wefting						
A—2-fold 18's bi-fibred yarn	50%/50%		Cotton & Wool	2	21	21	21	19	=96 ends in Pattern.
B—2-fold 16's ,, ,,	90%/10%		,, ,,	3	–	–	–	–	
C—2-fold 16's ,, ,,	90%/10%		Wool & Cotton	–	3	–	3	–	
D—2-fold 18's ,, ,,	80%/20%		,, ,,	–	–	3	–	–	

For wool dye in the piece. 17's reed 3 ends in a dent. 48 picks per inch.

68. *Variation of Textural Features.*—The textural features are variable by re-adjusting the shuttling plan, but not in tone gradation or in tinted composition, only as may be effected by changing the colour matched in dyeing, as from a warm tone of brown to a pale tone of green, mellowing the whole tinted scheme. In illustration of the pattern types obtainable in the weaving of this cloth without any re-arrangement of the yarns in the warp, the weftings are alterable thus: (1) Shuttle with yarn A, and (2) with yarn B; (3) transpose, in the order of colouring, the positions of yarns A and B, and (4) of yarns B and D; and (5) interchange the places of yarns A and C, and of yarns B and D. Five different styles would on this principle be woven, each adapted for the

same dyeing practice as the original texture. By the first and second wefts, striped patterns, instead of a checked combination, would be acquired, one having a tinted-white, and the other a dark-coloured, ground; by the third, the ground shades, grey and tinted white in Fig. 24, would alternate in position; by the fourth, the toning of the ground would remain constant but the heavier dark lines in the warp would be crossed with the intermediate-shade units and *vice versâ;* and, by the fifth order of shuttling, the relation of both the ground and checking yarns would be transposed.

FIG. 26

TWO-SHADE PATTERN—BI-FIBRED YARN FORMATION

If it should be assumed that the texture is coloured in the loom, substituting a light fawn for yarn A, a brown tone for B, deep brown for C, and medium brown for yarn D, a toned pattern would be formed to which the complete series of weft-ing re-arrangements indicated would be applicable. But, in using dyed yarns,

FIG. 27

I. MODIFICATION—PATTERN, FIG. 26

different colours, as distinct from shade tones, might be employed, such as dark and tinted blue for threads A and C, pale green for B, and an intermediate olive tone for threads D. Moreover, each of these warp yarns could be crossed, in the shuttling, with other colours, *e.g.*, blue and tinted blue with grey and light grey, pale green with lavender, and olive with medium green. Provided, as should be the case, the weft colours should correspond in shade tone with those in the warp, the delineation of the style would harmonize in all points with that of the original standard. Both schemes of colour treatment and practice have a relative value. The loom scheme offers advantages in tinting quality, and the piece-dyed advantages in mixed toning as derived from the fibrous materials used in the manufacture of the yarn.

FIG. 28

II. MODIFICATION—PATTERN, FIG. 26

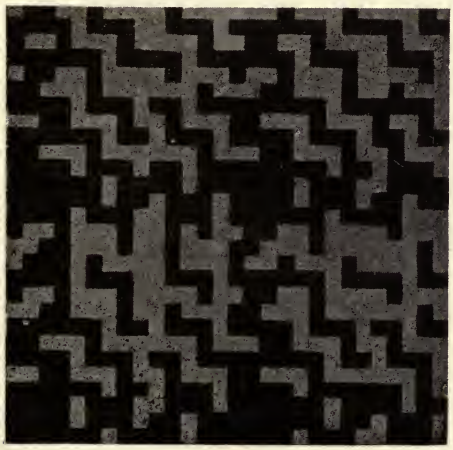


FIG. 29

III. MODIFICATION—PATTERN, FIG. 26

69. *Facilities in Experimental Pattern Production.*—It will be obvious that the former method presents special facilities

to the colourist in experimental pattern production. A varied assortment of yarns in solid and mixture colours—tones and tints—is the elastic basis on which range making is formulated. The designer works with selected colour units, which may be compared, classified, and harmoniously arranged before the fabric is woven. The technologist, working with bi-fibred yarns, depends on another species of technical data, for the tinted quality obtained in the finished manufacture. These are deduced from experimental investigations in yarn manufacture, and in the behaviour, in the dyeing process, of threads of a specific filament composition.

70. *Methods of Style Origination.*—The scheme of bi-fibred textile colouring originated, and illustrated in Tables IV to X and in Figs. 6 to 10, lends itself to standardization, inasmuch as new graded types of yarns may, with the productive exigencies, be added, and their colour contrasts registered in the chromatic scale of tones for reference in pattern designing, and in the construction of new cloths. Employing this scheme as a basis of dyed tinted results, the practice in making typical styles of effect in the grey, and of obtaining their development in definite mixture shades in the finished piece, has now been analysed and elucidated. It should be noted that, where the form of the pattern is not a standard type, a correct sketch should be prepared on point paper in the toned gradation in which it is intended to be expressed in the dyed fabric. This sketch should be modified on the principle followed in style elaboration in loom colouring, comprising the possible variations in the admixture of the yarns in the orders of warping and wefting. Referring, for example, to the pattern sketch in Fig. 26 (woven in the common twill) it would, in range making for a piece-dyed colour product, be diversified in yarn grouping as shown in the formula drafted on the next page.

TABLE XI

METHOD OF STYLE ORIGINATION AND EXTENSION
ORDER OF WARPING AND WEFTING

A—*Dark Shade* = No. 1, Table VII. B—*Medium Shade* = No. 3, Table VII.
C—*Light Shade* = No. 5, Table VII.

BASIC ORDER	= 4 threads of A,	3 threads of B,	4 threads of A,	3 threads of B	= Fig. 26
1ST MODIFICATION	= 4 ,, ,, A	3 ,, ,, B	4 ,, ,, A	1B 1A 1B	= ,, 27
2ND MODIFICATION	= 4 ,, ,, A	1B 1A 1B	4 ,, ,, A	1B 1A 1B	= ,, 28
3RD MODIFICATION	= 4 ,, ,, A	1B 1A 1B	1A 2B 1A	1B 1A 1B	= ,, 29
4TH MODIFICATION	= 1C 2A 1C	1B 1A 1B	1A 2B 1A	1B 1A 1B	= ,, 30

Five species of effect are implied, Figs. 26 to 30. Each pattern is distinctive in character, though a pure derivative, as seen from the grouping of the yarns in the modified orders, of the basic plan of warping and wefting. A third sort of yarn, C, (= a light shade in dyeing) is introduced into the fourth modification for giving the overchecking lines observed in Fig. 30. In colouring in the loom this yarn could be of a different hue from shades A and B, but by this practice it can only be developed in a third tone, either lighter or darker as considered advantageous. The relative contrasts in such style origination, whether the cloth is dyed a dark, intermediate or other colour, follow the yarn gradations, and are not variable without their alteration.

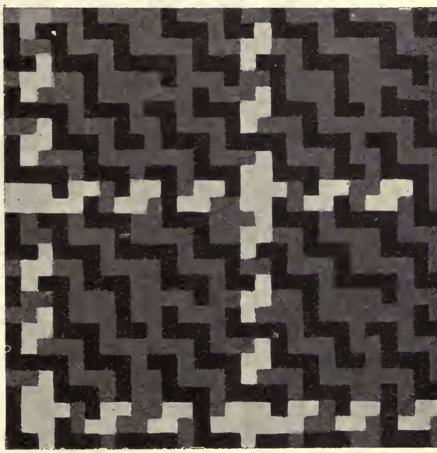


FIG. 30

IV. MODIFICATION—PATTERN, FIG. 26

The production of the range in yarn sorts instead of in yarn

colours, is accomplished by warping 4 threads of A and 3 threads of B, Fig. 26, and matching in the shuttling. This would be succeeded by changing the order of the yarns to that specified in the first modification, Fig. 27, and the weaving of the necessary length of cloth for the experiment—repeating this procedure for each modification included in the range.

FIG. 31

THREE-SHADE PATTERN—BI-FIBRED FORMATION

In addition to the matched weftings, forming checked combinations, other methods of weaving would be practised. For instance, striped effects are obtainable in each arrangement of yarns by wefting with yarn A or B, or an all-wool yarn ; and irregular types by shuttling in various ways, as 2 picks of A and 1 pick of B ; 4 of A, 1 of B and 1 of A, etc. The latter schemes should be devised in accordance with the rule applied to cross-wefted patterns in combining coloured yarns, that is, adapted to the warping plan and the weave structure.*

* See Chapters VIII and IX, *Colour in Woven Design.*

71. *Diversification of Shade Tones and Experiment in Design.*—Experiments carried out on these lines result in a series or range of patterns equally diversified in textural elements to those producible by using coloured warp and weft threads, and offer the advantage of being developable in a number of shade tones. The loom system of construction provides for more varied tinting in each style, but not for its manufacture in different colours, light or dark in shade. Combining bi-fibred yarns enables this to be done by changing the dyed colour as illustrated in Figs. 31, 32 and 33. Here the orders of the yarns in the warp and the weft coincide with the basic scheme and with the second and fourth modifications in Table XII, the weave plans being $\frac{2}{2}$ mat, and $\frac{2}{2}$ and $\frac{3}{3}$ twills. Fig. 31 is suggestive of dyeing the cloth a dark shade, Fig. 32 an intermediate, and Fig. 33 a light tone of colour. Following the method of experiment detailed in reference to the preceding example, the basic arrangement of the yarns would be elaborated as shown below.

TABLE XII

STYLE ORIGINATION AND EXTENSION—COMPOUND OF THREE-YARN STRUCTURES

A—*Dark Shade* = No. 2, Table VIII. B—*Intermediate Shade* = No. 5, Table VIII. C—*Light Shade* = No. 8, Table VIII.

BASIC ORDER	= 5	threads of A			4 threads of B			5 threads of A				4 threads of C								
1ST MODIFICATION	= 5	,,	,,	A	1B	2A	1B	5	,,	,,	A	4	,,	,,	C					
2ND MODIFICATION	= 5	,,	,,	A	1B	2A	1B	5	,,	,,	A	1C	2A	1C						
3RD MODIFICATION	= 5	,,	,,	A	1B	2A	1B	2A	1C	2A		1C	2A	1C						
4TH MODIFICATION	= 1A	3B	1A		1B	2A	1B	2A	1C	2A		1C	2A	1C						

Both in this style and that represented in Figs. 26 to 30, the yarns specified contain a maximum percentage of wool fibre. For production in yarns of a more cotton quality and in light textures, the following percentages are applicable: for yarns A, 50 of cotton and 50 of wool; for B, 65 of cotton

FIG. 32

II. MODIFICATION, TABLE XII—
INTERMEDIATE-SHADE DYEING

FIG. 33

IV. MODIFICATION, TABLE XII—
LIGHT-SHADE DYEING

and 35 of wool ; and for C, 85 of cotton and 15 of wool. Dyeing the wool ingredient in the fabric an intermediate colour, would give the effects due to yarn A in a pale medium tone, to yarns B in a light tone, and to yarns C in tinted white.

FIG. 34

SHADE CONTRASTS—BI-FIBRED CARDED YARNS

Whatever the nature of the predominant staple in the cloth, the shade contrasts are accentuated by the degree of yarn differentiation, and reduced in value by the closeness with which the yarn qualities approximate each other. In Figs. 26 and 31, a mean tone distinction is developed by the ratio of the dyed (wool) fibre in yarns A and B being as 90 : 70 ; and, in Fig. 31, in yarns B and C as 70 : 55.—See Tables VII and VIII. To further emphasize the difference betwixt the dark and intermediate tones, an all-wool yarn would be substituted for threads A, inducing the quality of contrast observed in Fig. 34 (plan, Fig. 35), arranged 2 ends of woollen and 1 end of the bi-fibred mixture yarn B.

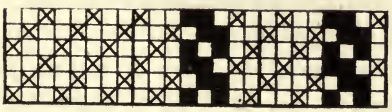


FIG. 35

SECTIONAL PLAN, FIG. 34

The possible gradation of tones which may be acquired in the yarn structures specified in Tables VIII is suggested by the style sketched in Fig. 36, and woven in swansdown weaves arranged as in Fig. 37, with the warp and weft yarns grouped—1 thread of shade No. 1, Fig. 9 ; 1 of No. 2, 1 of No. 3, and 1 thread of shade No. 4, piece-dyed, black or a dark colour. A clearer delineation of the effects is rendered practicable by combining yarns made of wool for shade 1, of 60 parts of wool and 40 parts of cotton for shade 2, of 40 of wool

and 60 of cotton for shade 3, and of 20 parts of wool and 80 parts of cotton for shade 4, matching a deep, an intermediate, or a pale colour in the dyeing of the texture, to agree with the brightness of tinted tone desired.

72. *Examples in Yarn Assortment and Pattern Construction.*— Examples in other assortments of yarn structures will be considered for the purpose of demonstrating the methods of acquiring the correct tone balance for defining the details features in the style. First, as exemplifying the species of contrast between the ground and pattern shade units, the textural types in Figs. 38 and 39 will be analysed. They are both compound checkings, one woven in the 2-and-2 twill cutting in 4's on eight threads and picks, and the other in four-shaft mat, and for which the yarns require to be classified as follows—

FIG. 38.—ORDER OF WARPING AND WEFTING

										66
Dark Shade	=(Solid worsted or 90 wool and 10 cotton)	3	1	4	4	3	1	4	4	
Intermediate Shade	=(70 wool and 30 cotton)	1	1	2	2	1	1	2	2	

FIG. 39.—ORDER OF WARPING AND WEFTING

		48					48				
Dark Shade	=(85 wool and 15 cotton)	2	1	2	1	–	2	2	2	2	–
Light „	=(30 „ 70 „)	1	–	1	–	2	2	–	2	–	2

In these examples two standard varieties of shade contrast, in the origination of ordinary checked styles, are illustrated, that in which the tone gradation is distinctive but subdued in character, and that in which it is strongly marked and well defined.

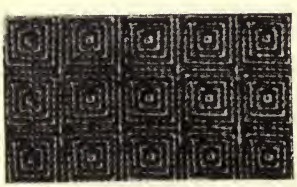


FIG. 36
KEY PATTERN—CARDED UNION YARNS

The specimens in Figs. 40 and 41 show other features in the finished fabric than those visible in the photographic reproductions. The darker and lighter tones in Fig. 40 are more closely related than is evident in the illustration, and the distinction between the light shades in

the two specimens is also more clearly observed in the original than in Figs. 40 and 41. The systems of construction

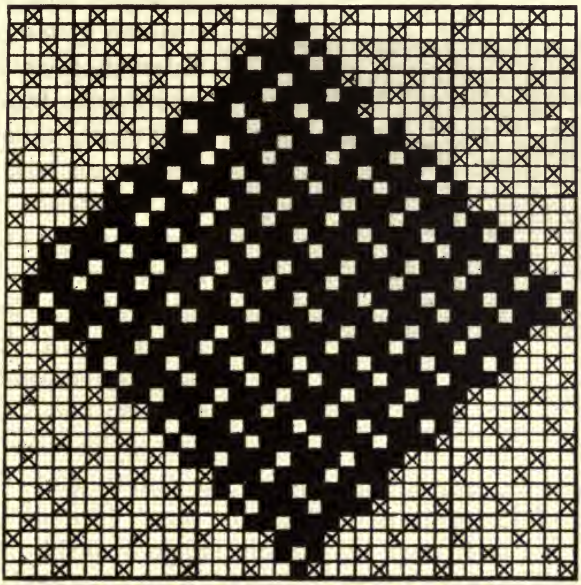


FIG. 37

PLAN FOR FIG. 36

appended are for the acquirement of the textural contrasts as these appear in the piece—

FIG. 40.—ORDER OF WARPING AND WEFTING

Dark Shade = (80 wool 20 cotton) 2
Intermediate Shade = (60 ,, 40 ,,) 2

Weave Plan: Pick 1, $\frac{1\ 1\ 1\ 2}{1\ 2\ 2}$; Pick 2, $\frac{2\ 1\ 1\ 1}{2\ 2\ 1}$; Pick 3, $\frac{1\ 3\ 1}{1\ 2\ 1\ 1}$;

Pick 4, $\frac{1\ 1\ 3}{2\ 1\ 2}$; Pick 5, $\frac{3\ 1\ 1}{1\ 2\ 2}$; etc.

FIG. 41.—ORDER OF WARPING AND WEFTING

Dark Shade = (85 wool 15 cotton) 4 2
Light ,, = (50 ,, 50 ,,) 4 2

Weave Plan: Picks 1 and 2, $\frac{4}{4}$; Picks 3 and 4, $\frac{4}{2\ 2}$; Picks 5 and 6, $\frac{4}{4}$;

Picks 7 and 8, $\frac{2\ 2}{4}$; etc.

73. *Yarn Distribution and Shade Toning of the Cloth.*—From these examples, and also those illustrated in Figs. 26 to 33, it will be understood that the system of yarn distribution, and of yarn assortment, in bi-fibred textures, follows the shade tones requisite in the expression of the pattern types. This fundamental principle applies to all varieties of this class of design in single, compound, and irregular builds of fabric. The styles dissected are applicable to elementary weave structures, and illustrate the use of the weft as well as the warp yarn for textural toning. As such they are equally adapted to thin, medium, and heavy makes of manufacture. Moreover, each style is weavable in a cotton, woollen, worsted or other grade of union production, and is, as a standard yarn grouping, colourable in tinted, toned or dark shades.

Fig. 38

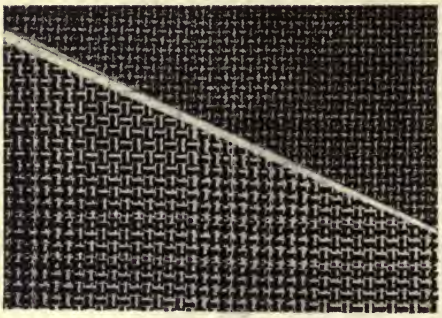


Fig. 39

BI-FIBRED COMBED YARNS—EXAMPLES IN SHADE CONTRASTS

Fig. 40

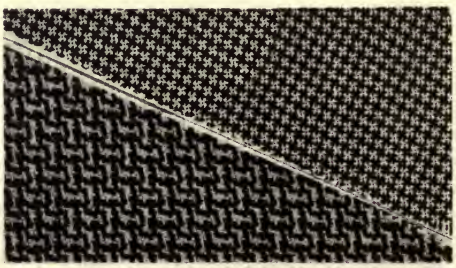


Fig. 41

BI-FIBRED COMBED-YARN SPECIMENS

Restricting the effects to the tones obtainable in the warp yarns detracts from the general utility of the pattern product, but enables special varieties of design and qualities of texture to be constructed. An examination of the styles illustrated in Figs. 42, 44 and 46 will make these points evident. The looming designs—Figs. 43, 45 and 47

are arranged on the warp-face scheme of intertexture, concealing the weft in the fabric, and bringing the different sorts of warp threads on to the surface for the formation of the details in the style. The designs have, in the texture, the character of ordinary weave types when woven in a lighter shade of warp than weft yarn. But, as seen from the plans,

FIG. 42

WARP-TWILL STRIPE

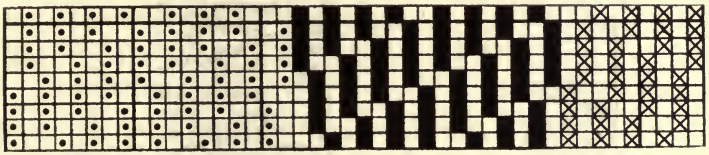


FIG. 43

SECTIONAL PLAN FOR FIG. 42

the complete series of textural elements in each specimen is a product of the warp schemes of interlacing, these being contrived on a warp cord basis but twilled, matted, waved or otherwise varied in the intersection groupings. If Fig. 42 were coloured in the loom it would be warped end-and-end, dark and medium shades in the ground sections, and one dark and one light in the fine striping; and woven with an intermediate shade of weft yarn. On the bi-fibred yarn principle, the yarn for the dark shade would consist of 85

FIG. 44

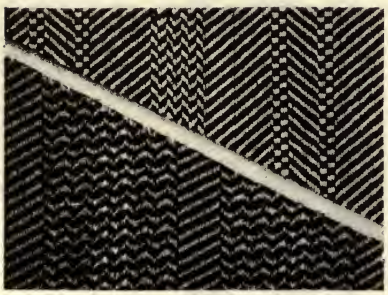


FIG. 46

THREE-SHADE PATTERNS—BI-FIBRED COMBED YARNS

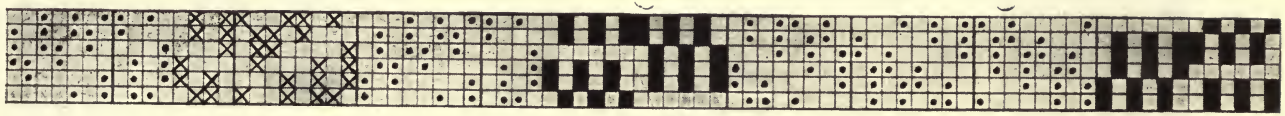


FIG. 45

PLAN FOR FIG. 44

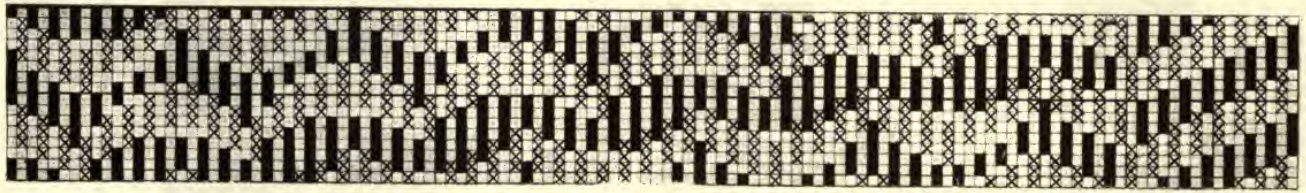


FIG. 47

PLAN FOR FIG. 46

parts of wool and 15 parts of cotton, for the medium shade of 55 of wool and 45 of cotton, and for the light shade either cotton or a yarn containing 90 parts of cotton fibre would be used. The weft should be of the same counts as the warp but be composed of 70 per cent. of wool, taking a shade tone between the medium and the dark tones in the colouring of the piece.

Corresponding assortments of yarn are adapted to the weaving of the specimens in Figs. 44 and 46, with slight variations in the positions of the threads for the light-toned features, as those defined for Fig. 42. The three patterns exemplify the practice of producing in the same looming or warping draft, several distinct pattern styles, each suitable for range making by the method of tinting followed. The design structures—Figs. 43, 44 and 45—differ in arrangement and composition, but result from a common principle of intertexture.

74. *Effect of Elaborating the Weave Basis, with Specimens.*—Elaborating the weave basis, and utilizing the weft yarn in the production of the features in the style, enable a more diversified class of pattern to be originated. An effective scheme of range-making, in a comparatively small number of yarn standards, is thus formulated. The resultant textures are variable in thickness and weight per yard, though not necessarily in filament manufacture. It is a matter of employing designs, arranged as to plan of warp and weft intersections and as to structural units, in accordance with a specific order of warping and wefting. Selecting, for this purpose, the one-and-one (with modifications) arrangement alluded to, and, for shuttling, one sort of weft yarn, and two sorts grouped pick-and-pick and 3-and-3, the specimens in Figs. 48, 50, 52 and 54 are typical of the principles of pattern work comprised. The weave plans—Figs. 49, 51, 53 and 55—show how the design elements are combined and made to fit with the classification of the yarn sorts in the loom for deciphering the toned contrasts in the dyed fabric. For the dark

tones, warp and weft, the yarns consist of 80 per cent. of wool (A), or the medium tones of 60 per cent. (B), and for the light tones of 40 per cent. of wool (C), cotton being the other fibrous ingredient. The light striping in Figs. 48 and 50 is the consequence of using cotton or silk threads in the whip cord weave, and in the place of (C) in the warping, Fig. 50. Analysing the examples in relation to the point paper designs, Fig. 49 is warped thread and thread in the two mixture yarns equivalent to the medium and light tones in the fabric, and wefted with the yarn containing 80 per cent. of wool fibre. The plan of the intersections both here and in Fig. 51—healded 1 end of (A) and 1 end of (B), and wefted 1 shot (C) and 1 shot (B)—resembles that in Figs. 43, 45, and 47; but in the latter the weft interlacings are separate one from the other, whereas in these combinations they are linked together and form compact weft twilled lines. Such lines in Fig. 49 are chintzed and in Fig. 53 intermingled by being picked 3 shots of (A) and 3 shots of (C).

FIG. 48

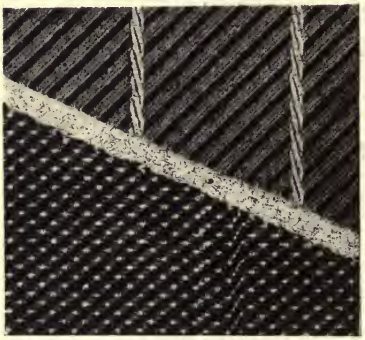


FIG. 50

PATTERNS IN BI-FIBRED WARP AND WEFT YARNS

FIG. 52

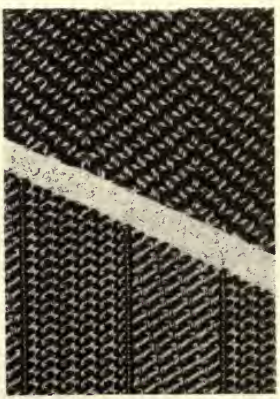


FIG. 54

WEAVE COMPOUNDS IN BI-FIBRED COMBED YARNS

75. *End-and-End Warping and Compound of Three Weave Types.*—Fig. 55 is composed of three weave elements, sections I and II being colourable one-and-one in the warp, and the ribbed section III suitable for production in one shade of yarn. It

illustrates a further principle of work, that of developing special details (marked in ■'s in the design) in the weft yarn

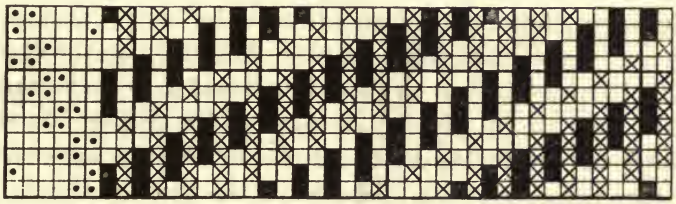


FIG. 49

PLAN FOR FIG. 48

(A), emphasized in the texture by being contiguous with the light shade details due to the warp threads (C). Section I is loomed 1 of thread (B) and 1 of thread (C), but section II 1 of (A) and 1 of (C) for four ends, then 1 of (B) and 1 of (C) for a like number of threads. Each example is suggestive of a distinct variety of design applicable to a common scheme of warping and yarn assortment. The thread structures defined are effective in the production of dark toned patterns; but, by reducing the percentages of the wool fibre to 50, 30 and 10 for the deeper, intermediate and light shades, yarns are obtainable which give unions of a cotton character and which are adapted for dyeing in brighter colour tones and for developing the pattern in graded mixture tints.

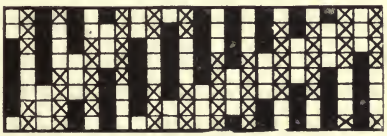


FIG. 51

SECTIONAL PLAN FOR FIG. 50

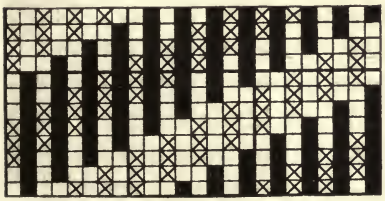


FIG. 53

PLAN FOR FIG. 52

76. *Mingled-shade Tones and Pattern Definition.*—The whole scheme of bi-fibred manufacture involves the production of intermingled colour toning in the fabric. It follows that the

pattern types are not so clearly defined as in the use of solid shades, that is, in the combination of coloured yarns in the looming. The delineation of the component features of a design may, however, be accentuated by strengthening the mixture shade contrasts. If, for example, the technical details in such patterns as those illustrated in Figs. 26 and 31 should not be sufficiently distinguishable and pronounced in the dyed texture, the defect may be remedied by augmenting the yarn differentiations. Instead of the yarn units specified for the respective shades, yarns equivalent to giving tones 1, 3 and 5 or 1, 5 and 7, Fig. 10 would, in these instances, be found more satisfactory. But this shade scale—Table X—is constructed for four-toned mixture colours, graduating from dark to light, in threads of an even fibrous analysis, and applicable (1) to dark-toned patterns in the first series—1 to 4—to (2) medium-toned patterns in the second series—4 to 6—and to (3) light-toned patterns in the third series—7 to 9—each series being intended for separate dyeing operations. Now it is a question of producing shades of an effective tone gradation when dyed in one process, implying yarns of a greater filament dissimilarity than those described in Tables IX and X. Two methods of work may be adopted, first, a four-tone scheme, with the proportions of the two fibres—wool, cotton, etc.—in the ratios of 90 : 10, 70 : 30, 50 : 50, and 30 : 70 ; and, second, a nine-tone scheme, with the wool and cotton in the ratios of 90 : 10, 80 : 20, 70 : 30, 60 : 40, 50 : 50, 40 : 60, 30 : 70, 20 : 80, and 10 : 90. Both practices are sound, but the latter offers the fuller scope in fabric tinting. It includes the shades in the first system, and provides a complete scale of tones, running, in mathematical ratio, from a deep dark shade to a clear light tint. Another element to consider is the nature of the colour of the cotton on vegetable fibre. This, as previously stated, may be in the natural shade or dyed a similar or contrasting hue to the colour matched in tinting the piece. In any case, it is essential the cotton should be a pure tint, resembling a stained white, and not a

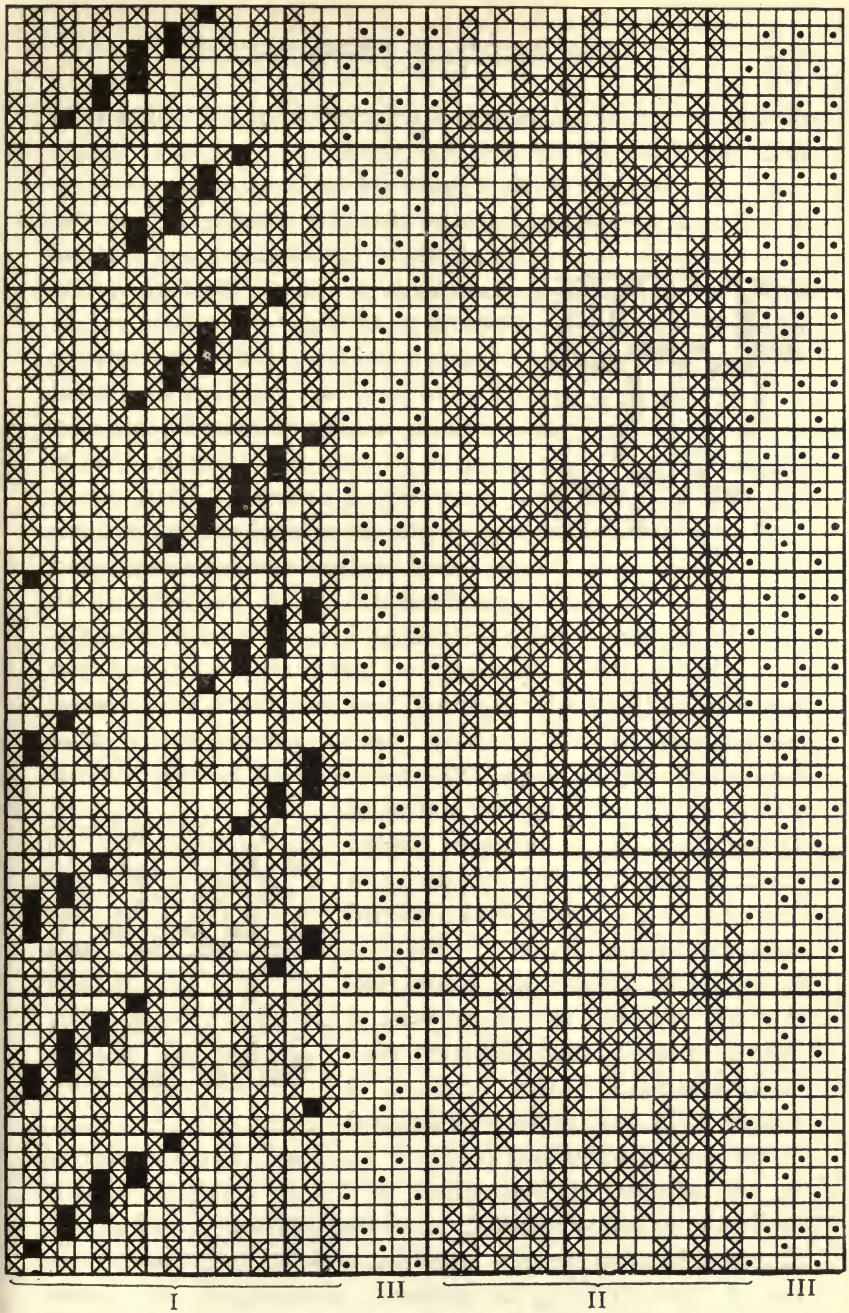


Fig. 55

DESIGN FOR FIG. 54

distinctive colour, otherwise it deteriorates the quality of the scale gradation.

77. *Application of Nine-tone Scheme.*—Assuming, for exemplification purposes, that the nine-tone scheme is employed, and that the fibrous percentages indicated give yarn structures representative of the tone values of the shade units Nos. 1 to 9 inclusive in Fig. 10, the uses of the yarns in the ordinary classes of manufacture offer salient points for analysis. Their intermingled nature yields a species of tinting between that of a piece-dye all-wool texture and a coloured-yarn production. The consequence is bi-fibred threads yield a distinctive class of weave definition as arising from the toning contrast betwixt the warp and weft elements in the cloth. Twilled, mat and other fundamental crossings are known to have special characteristics when applied to cotton, linen, silk, woollen and worsted fabrics whether woven in the grey, and dyed in the piece, or in coloured yarns. Each weave principle produces a different build of fabric, and a special variety of textural effects. When it is desired to render the latter particularly distinct, the warp yarn is lighter in shade than the weft yarn or contrariwise. The lines of a simple twill, alternately developed in threads of warp and picks of weft, are thus accentuated by the contrast in the colour of the two yarns. This is really the technical method, in all-wool, cotton or silk goods, of enforcing the weave features, without resorting to the use of yarns differing in thickness, construction, or material quality. Now the filament grading, in the spinning of

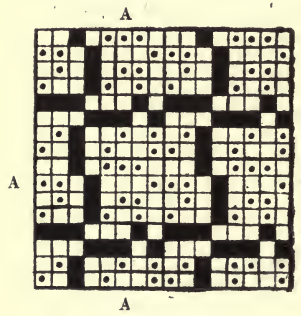


FIG. 56

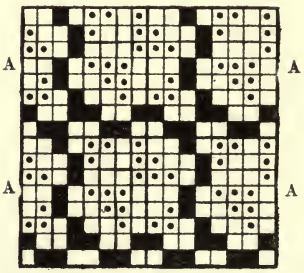


FIG. 57

bi-fibred threads, enables the interlacings of the warp to be clearly distinguished from those of the weft, with the cloth dyed in a single process and one colour. If the yarns only differ in degree in fibre composition, a shade contrast is induced, and this lends precision and character to each group of intersections. The extent to which these qualities are derivable from the yarn, in the dyeing of the fabric, is determined by the filament units in the warp and weft threads, or by the relative positions of the two yarns in the tone scale. Thus, for decided contrasts, the wool and cotton ratios for the warp should be such as 30 : 70 or 10 : 90, and for the weft as 90 : 10 or 80 : 20; for slightly defined contrasts, warp, 65 : 35; weft, 75 : 25, etc., and for contrasts moderately pronounced, warp, 60 : 40 or 50 : 50; weft, 80 : 20 or 70 : 30; which would result, in each arrangement, in the warp yarn (*i.e.*, warp effects in the cloth) being in the lighter, and in the weft being in the darker tone.

78. *Indefinite and Decided Contrasts.*—An index is supplied, in Tables XIII and XIV, of the serial grades of indefinite and decided contrasts obtainable, by these methods, in the combination of bi-fibred warp and weft yarns in the weaving of the fabric and by piece dyeing.

TABLE XIII

INDEFINITE AND MEZZOTINT CONTRASTS

(Shade Nos. and Tone Values as in Fig. 9; Yarn Structures as in Table IX.)

Scheme.	Warp.	Weft.
A	Toned Dark Shade, No. 2	Very dark Shade, No. 1
A^1	,, ,, ,, No. 3	Toned ,, ,, No. 2
A^2	Dark Shade No. 4	,, ,, ,, No. 3
A^3	Toned Dark Shade No. 3	Very ,, ,, No. 1
A^4	,, ,, ,, No. 4	Toned ,, ,, No. 2
A^5	,, ,, ,, No. 4	Very ,, ,, No. 1
B	Toned Medium Shade, No. 6	Deep Medium Shade, No. 5
B^1	Medium Shade No. 7	Toned ,, ,, No. 6
B^2	Tinted Medium Shade No. 8	Medium Shade No. 7
B^3	Medium Shade No. 7	Deep Medium Shade No. 5
B^4	Tinted Medium Shade No. 8	Toned ,, ,, No. 6
B^5	,, ,, ,, No. 8	Deep ,, ,, No. 5

Contrasts A, A^1 and A^2, and B, B^1 and B^2 are very slightly defined. Those in A^3 and A^4, and in B^3 and B^4 are a degree more pronounced, while those in schemes A^5 and B^5 are sufficiently marked to exhibit the two series—warp and weft—of interlacings in the texture, especially in bi-fibred worsteds and cottons, though the distinctive tones of the two yarns are less evident in bi-fibred woollens.

79. *Toned and Mezzotint Contrasts.*—These colour tones are adapted for the manufacture of shaded or shot effects in the cloths of the variety referred to in Paragraphs 70, 71, and 74 by arranging the yarns in simple orders for striping and checking as on the lines suggested below—

TONED AND MEZZOTINT CONTRASTS—EXAMPLES IN THIN WOOLLEN TEXTURES

I.—Warp and Weft :	4	threads of	shade	1	(Fig. 9, Table IX)	
	4	,,	,,	2	,,	,,
II.— ,, ,,	8	threads of	shade	5	,,	,,
	8	,,	,,	6	,,	,,
III.— ,, ,,	16	threads of	shade	8	,,	,,
	8	,,	,,	6	,,	,,
	8	,,	,,	5	,,	,,
	8	,,	,,	6	,,	,,

TONED AND MEZZOTINT CONTRASTS—EXAMPLES IN BI-FIBRED WORSTEDS

I.—Warp and Weft : For 24	2	threads of	shade	2	(Fig. 9, Table X)	
	2	,,	,,	3	,,	,,
For 24	4	,,	,,	2	,,	,,
	4	,,	,,	3	,,	,,
II.— ,, ,,	6	threads of	shade	4	,,	,,
	6	,,	,,	5	,,	,,
	6	,,	,,	4	,,	,,
	3	,,	,,	5	,,	,,
	3	,,	,,	4	,,	,,
	3	,,	,,	5	,,	,,
III.— ,, ,,	4	threads of	shade	3	,,	,,
	4	,,	,,	1	,,	,,
	4	,,	,,	3	,,	,,
	4	,,	,,	2	,,	,,
	4	,,	,,	4	,,	,,
	4	,,	,,	2	,,	,,

In costume, flannel, and thin textures, the proportionate quantities of the shade units may be considerably increased; but, as in suiting cloths, patterns of the lesser type are usually selected, the thread factors quoted are suggestive of those which should be combined.

80. *Accentuated Warp and Weft Contrasts.*—

TABLE XIV

ACCENTUATED WARP AND WEFT CONTRASTS

(Shade Nos. and Tone Values as in Fig. 10; Yarn Structures as in the Nine-tone Scheme, Paragraph 76.)

Scheme.	Warp.	Weft.
A	Mixture Shade, No. 5	Mixture Shade, No. 1
A^1	,, ,, No. 6	,, ,, No. 2
A^2	,, ,, No. 7	,, ,, No. 3
A^3	,, ,, No. 8	,, ,, No. 4
A^4	,, ,, No. 9	,, ,, No. 5
B	Mixture Shade, No. 6	Mixture Shade, No. 1
B^1	,, ,, No. 7	,, ,, No. 2
B^2	,, ,, No. 8	,, ,, No. 3
B^3	,, ,, No. 9	,, ,, No. 4
C	Mixture Shade, No. 7	Mixture Shade, No. 1
C^1	,, ,, No. 8	,, ,, No. 2
C^2	,, ,, No. 9	,, ,, No. 3
D	Mixture Shade, No. 8	Mixture Shade, No. 1
D^1	,, ,, No. 9	,, ,, No. 2
E	Mixture Shade, No. 9	Mixture Shade, No. 1

As these yarns differ in filament structure they offer, in weaving practice, considerable latitude in the origination of textural and tinted contrasts. Their use in the form of warp or weft, and not in irregular quantities as integral but as sectional parts of the fabric, results, in each yarn grouping specified, in the manufacture of a level piece and of a symmetrical tensile standard. The decisiveness and strength of the tone contrasts augment from A to A^4, B to B^3, C to C^2, and from D to E.

81. *Tone Contrasts and Weave Types.*—The subject is capable of dissection in reference to special design types, in

the development of which study and experiment, in the spinning, weaving and dyeing of bi-fibred structures, should lead to the fabrication of new and economic grades of woven goods. It has been shown how colour pattern, which represents one branch of textile design, is devised, constructed and elaborated in these manufactures. A second phase of the designing art consists in the definition in the fabric of weave elements, inclusive of the many variations of weave compounds available in the origination of textural style as a pure product of warp and weft systems of intersection. If a clear

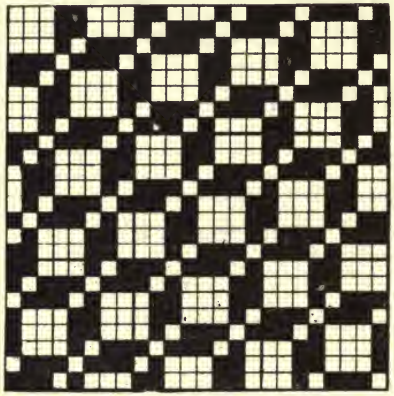


FIG. 58

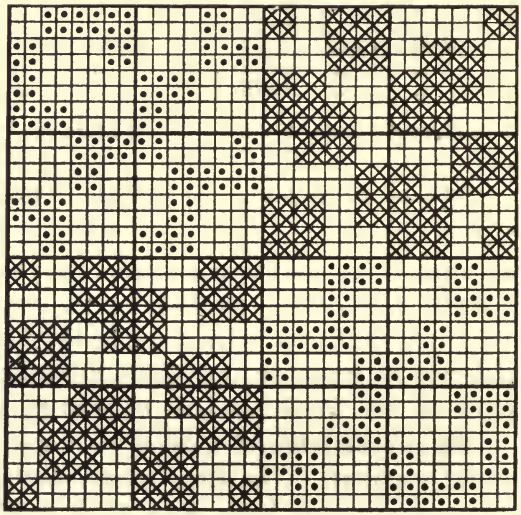


FIG. 59

distinction may be made in the appearance in the cloth, and in the warp and weft crossings in the plain weave ; and if these

crossings, as explained, may be toned in degree of accentuation, the ground principles, of this scheme of work, are of a similar extensible character as those applied in the assortment of coloured-thread units in the production of the fabric. Provided the range of shade contrasts in Tables XIII and XIV, there is, with the exercise of technical knowledge of the toning

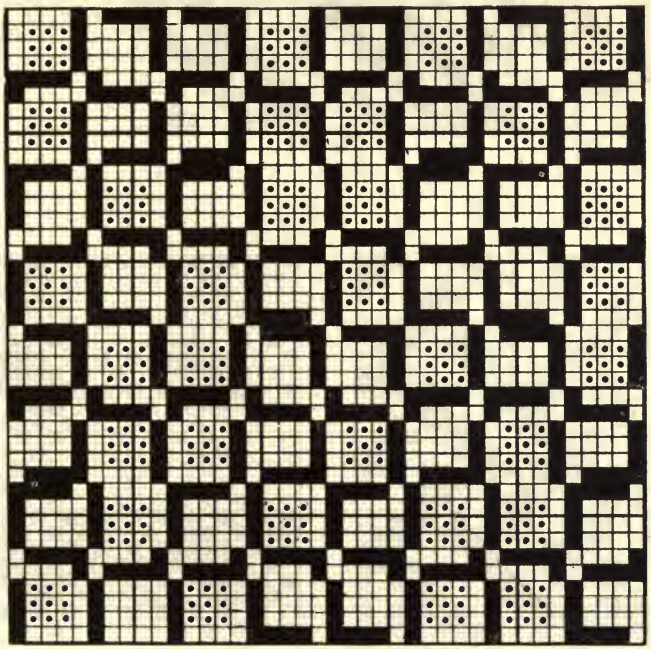


Fig. 60

values of given bi-fibred yarns, ample facility for expressing textural as distinguished from colour patterns, in fine detail or broad and well-emphasized warp and weft types in whatever form they may be planned and grouped.

82. *Design Elements and Manufacturing Practice—Illustrated.*—The principles involved may be dealt with by taking a number of weave structures, and weave combinations, and explaining the practice of manufacture to be pursued in their effective delineation in the dyed cloth. Of these examples the crêpe

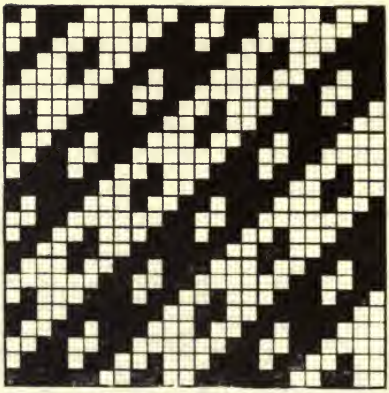


Fig. 61

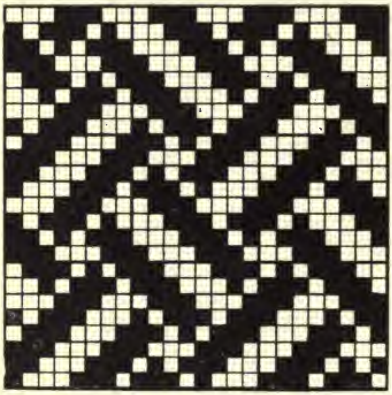


Fig. 62

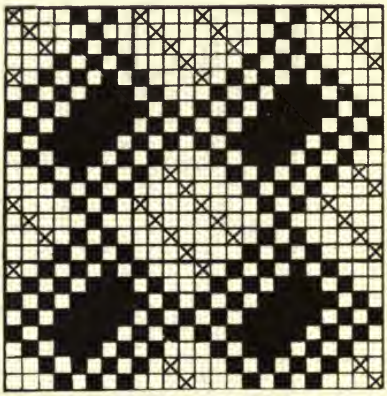


Fig. 63

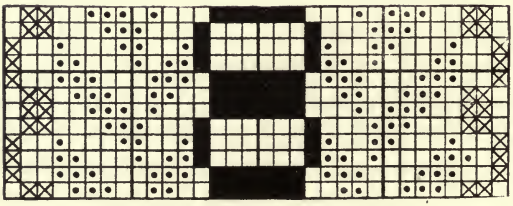


Fig. 64

class of weave is the least pronounced in intersection elements, and, as such, it is not readily definable in respect to the warp and weft effects of which it is composed. Figs. 56 and 57, page 100, are two modified specimens, the checking lines having been added to exemplify the method of developing both the ground, and the special interlacings, in separate shade tones by arranging the yarns thus—

Warp

2 threads of mixture shade 5. (See Table XIV for Yarn Structure)
2 ,, ,, ,, 9 ,, ,, ,,
6 ,, ,, ,, 5 ,, ,, ,,

Weft

2 picks of mixture shade 1 or 2, (See Table XIV for Yarn Structure)
2 ,, ,, 9 ,, ,, ,,
6 ,, ,, ,, 1 or 2 ,, ,, ,,

This yarn scheme produces sections A, Figs. 56 and 57, in a medium shade of warp and a darker shade of weft, and the checkings in a lighter tone, the three yarn structures combined exhibiting these toning distinctions in the tinted piece.

When the weave plans are formed of interlacing units, which, in themselves, yield warp or weft effects contrasting with each other, tone differentiation is applied for moderating or accentuating their distinctive character, as indicated in the schemes of yarn assortment for Figs. 58 to 63.

FIGS. 58 AND 59

Schemes A^3, B^2, and B^4, Table XIII

FIG. 60

Warp

1 thread of shade No. 2, Table XIII
4 threads ,, 7 ,,
1 thread ,, 2 ,,

Weft

1 pick of shade No. 2, Table XIII
4 picks ,, 5 ,,
1 pick ,, 2 ,,

FIG. 61
Schemes A, B, C, and D, Table XIV

FIG. 62
Schemes A^4 and B^4, Table XIII

FIG. 63
Schemes A^5, B^1, and B^5, Table XIII

Figs 58 and 59 are both formed of compact warp and weft elements, which only require a moderate shade contrast to

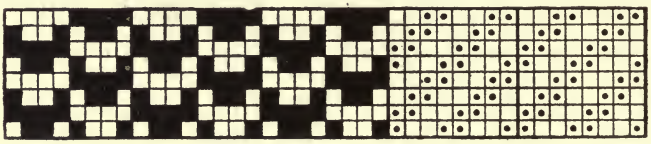


FIG. 65

develop them individually in the texture. In scheme A^3 they would be just distinguishable in dark tones, and similarly marked in B^2 but in medium tone, whereas in B^4 the two series of units would be quite distinct. Fig. 60 is a type of weave plan adapted to a special yarn grouping. In that indicated the threads and picks, arranged in pairs, are woven in a dark tone; and the warp intersections of the plan in a light, and the weft intersections in a medium shade, expressing each type of detail in a different mixture tone. In weaves in which the two sets of interlacings are inverted as in Fig. 61, warp and weft shades analagous to each other in

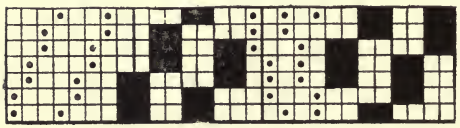


FIG. 66

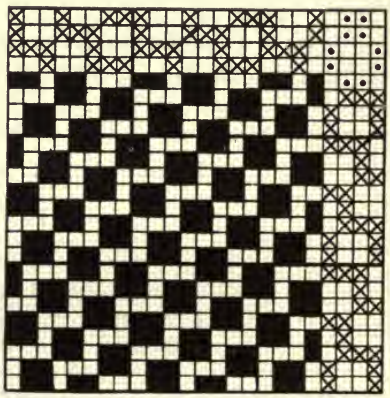


FIG. 67

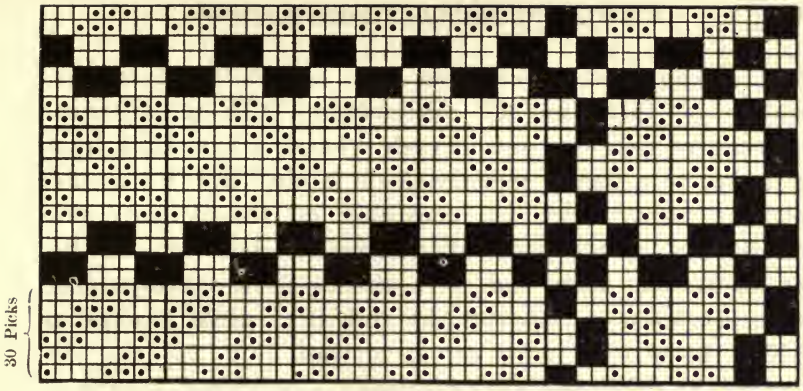


FIG. 68

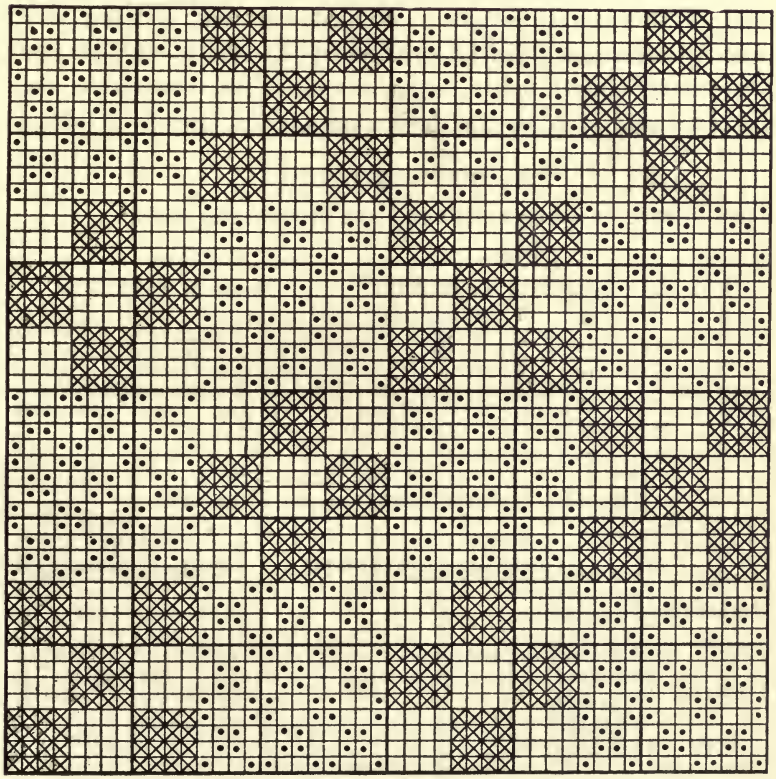


FIG. 69

tone are applicable, and these have been selected as illustrative of this basis of manufacture, with an identical measure of tone contrast in each scheme, but grading from a darker to a lighter mixture-shade fabric. The transposed plan of weave, Fig. 62, consisting of thread and pick interlacings of the same dimensions, is also suitable for production in warp and weft shades of a corresponding tone as shown in schemes A^4 and B^4; while weaves in which the textural units are in contrast (Fig. 63) may be defined in either slightly or strongly emphasized shades as indicated in schemes B^1 and A^5 and B^5.

83. *Shade Tonation in Striped, Checked and Figured Styles.*—A like latitude obtains in tone variation, definition and development of the weave factors in striped, checked, spotted, and figured patterns as will be evident in the effects of the yarn schemes tabulated below, when examined in relation to the character and style of the design product in the dyed fabric.

EXAMPLES IN STRIPES

FIG. 64.—3-AND-3 TWILL AND ELONGATED MATS

Warp	*Weft*
3 threads of shade 6, Table XIII	Shade 5, Table XIII
6 „ „ 7 „	
3 „ „ 6 „	
8 „ „ 8 „	
3 „ „ 6 „	
6 „ „ 7 „	
3 „ „ 6 „	

FIG. 65.—MATTED AND TWILLED COMPOUND

	Warp	*Weft*
For 8 Threads	1 thread of shade 9, Table XIV	Shade 3, Table XIV
	2 threads „ 7 „	
	1 thread „ 9 „	
For 8 Threads	1 thread „ 6 „	
	2 threads „ 4 „	
	1 thread „ 6 „	
For 8 Threads	1 thread „ 9 „	
	2 threads „ 7 „	
	1 thread „ 9 „	

	Warp	*Weft*
For 16 Threads	6 threads „ 7 „ 4 threads „ 9 „ 6 threads „ 7 „	As in Figs. 64 and 65.

FIG. 66.—WHIP CORD AND TWILLED MAT

	Warp	*Weft*
For 5 Threads	7 threads of shade 3, Table XIII 7 „ „ 5 „ 1 thread „ 1 „ 1 „ „ 7 „ 7 threads „ 5 „	Shade 1, Table XIV

EXAMPLES IN CHECKED STYLES

FIG. 67.—INVERTED TWILLED MAT

	Warp	*Weft*
For 20 Threads	1 thread of shade 7, Table XIV 1 „ „ 3 „ 1 „ „ 8 „ 1 „ „ 5 „ 1 „ „ 8 „ 1 „ „ 5	For 24 Picks 1 pick of shade 8 1 „ „ 5 1 „ „ 7 1 „ „ 3 1 „ „ 7 1 „ „ 3

FIG. 68.—CUT CHECK

Warp	*Weft*
32 threads of shade 3, Table XIII	30 picks of shade 2, Table XIII
4 „ „ 2 „	4 „ „ 1 „
8 „ „ 3 „	8 „ „ 2 „
4 „ „ 2 „	4 „ „ 1 „
	2 „ „ 2 „

FIG. 69.—CHECK IN WEAVE CONTRASTS

Warp	*Weft*
4 threads of shade 9, Table XIV	4 picks of shade 8, Table XIV
4 „ „ 7 „	4 „ „ 6 „
4 „ „ 9 „	4 „ „ 8 „
4 „ „ 8 „	4 „ „ 9 „
4 „ „ 6 „	4 „ „ 7 „
4 „ „ 8 „	4 „ „ 9 „

EXAMPLES IN FIGURED STYLES

FIG. 70.—WAVED PATTERN

Warp	*Weft*
6 threads of shade 6, Table XIV	Shade 4, Table XIV
6 ,, ,, 7 ,,	
6 ,, ,, 8 ,,	
8 ,, ,, 9 ,,	
6 ,, ,, 8 ,,	
6 ,, ,, 7 ,,	
6 ,, ,, 8 ,,	
8 ,, ,, 9 ,,	
6 ,, ,, 8 ,,	
6 ,, ,, 7 ,,	

FIG. 71.—SMALL LEAF PATTERN WITH CORD AND SATEEN GROUND

Warp	*Weft*
8 threads of shade 9, Table XIV	Shade 5, Table XIV
8 ,, ,, 7 ,,	
8 ,, ,, 9 ,,	

84. *Suitable delineation of Textural Details.*—The weave types in each of these examples are clearly but suitably defined in the several textures by the yarn units combined. Referring to the stripes, in Fig. 64, the sections twilling to the right, and in a reverse direction, are produced in separate shades but only differing to a small degree in tone. The part in elongated mat is woven in a third and lighter shade, while the weft is of a deeper tone than the darker mixture yarn in the warp, and this has the effect of developing each variety of textural detail. The fancy mat portion of Fig. 65 is divided into three stripings with the centre one in the darker tones, in contrast with the line features formed in the twilled stripe and developed in the lighter tones. Again, crossing with a deeper shade of weft emphasizes the elements due to the intersection schemes. The whip-cord stripe, Fig. 66, is hardly modified by the dark shuttling yarn, but the adjoining lines, in twilled mat, are distinctly brought out, while the end-and-end warping in the cord twill develops this section of the stripe in two shades of warp.

The principle in colouring the checked style in Fig. 67 is that of warping both the weave units in two light shades, and wefting pick-and-pick in two deeper shades, producing a "colour" and a "weave" pattern. For the cut check, Fig. 68, a further basis of toning is utilized. Here the form

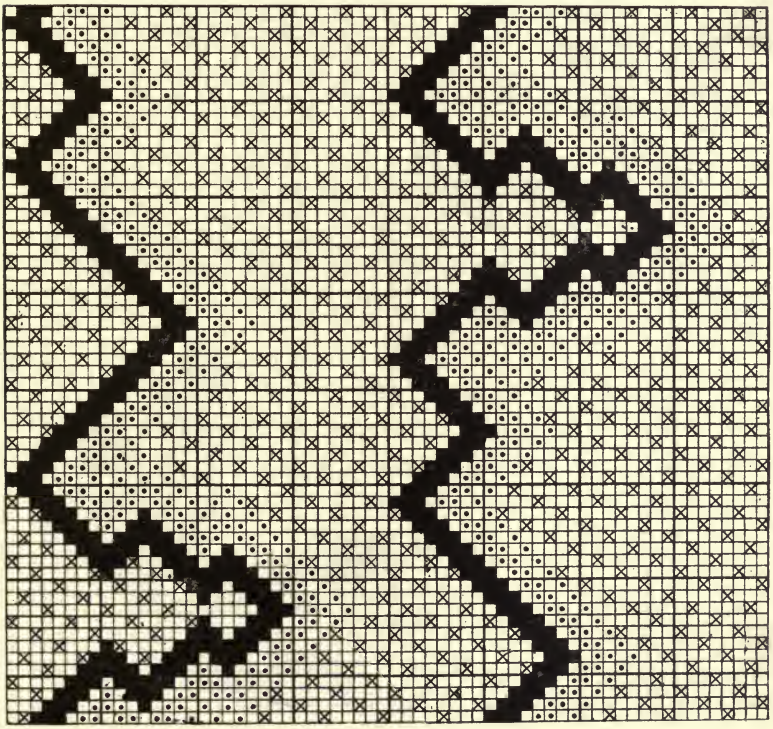


Fig. 70

of the design, due to the weave elements, is accentuated by using yarns in the warp of a lighter tone for the 3-and-3 twilling than for the mat cutting threads, and by crossing each of these yarns with a fuller-toned weft. Checked plans composed of weaves differing in intersection units—Fig. 69 formed of 2-and-2 and 4-and-4 mats—may be conveniently coloured by grouping the yarns to fit with either the lesser or

broader weave type. In the example the order of warping and wefting agrees with the 4-and-4 crossing, which is woven in two shades, but the lighter tone in the warp interlaces with the darker tone in the weft and *vice versâ*, an arrangement

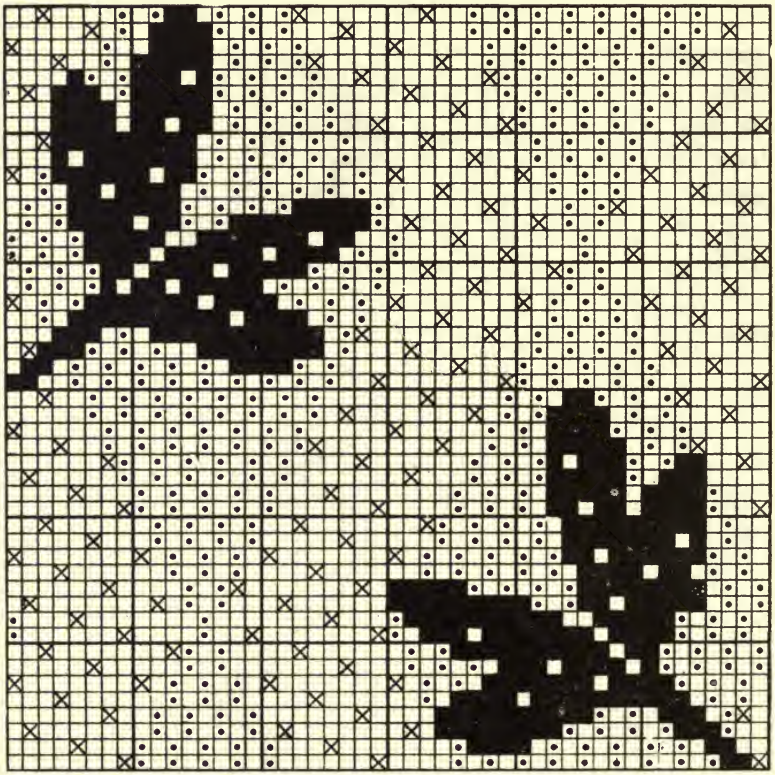


FIG. 71

which, in this class of combination, exhibits the structural character of both the smaller and larger weave.

85. *Figured Examples with Shaded Stripes in the Warp.*— In figured styles the leading features in the design, when acquired in the weft yarn, as in Figs. 70 and 71, allow of the warp being striped variously. The striping should not infringe on the clear development of the component parts of the

pattern, but form a natural setting on which the latter are rendered effective. For this branch of textile colouring bi-fibred yarns are specially applicable, inasmuch as they facilitate toning gradation, or the combination of shade units in mathematically determined degrees of contrast. In Fig. 70 the arrangement of the yarn types gives a shaded form of stripe, woven in warp sateen, and underneath the wave lines in weft twill and plain make ; and in Fig. 71 the two sorts of warp thread are grouped to produce well-spaced lines in light and very light tones, with the leaf figuring in a medium shade of mixture weft yarn.

The tone differentiation possible, in these and like specimens, is to be distinguished from colour variation, which is only restricted, in range, by the practice in shade matching in the dyeing of the goods.

SECTION II

COMPOUND-YARN FABRICS

CHAPTER V

PRODUCTIVE SCHEMES

86.—The Ordinary Type of Union-Twist Threads. 87.—Union Yarn a Basis of Textural Production. 88.—Twist Thread Structure and Manufacturing Latitude. 89.—Paramount Material Factor in Union Twists. 90.—Structural Variations in Union Yarns. 91.—Manufacturing Provision in Union-Twist Counts. 92.—Cotton and Linen Union Threads. 93.—Silk Twist Yarns. 94.—The Productive Problem—Tabulated Examples. 95.—Weft Thread—Filament Composition. 96.—Qualities of the Weft Yarn. 97.—Methods of Applying Two- and Three-fold Threads. 98.—Weave Elements and Twist-Yarn Goods. 99.—Union-Twist Yarn Fabrics—Tables. 100.—Worsted Union-Twist Textures. 101.—Compound Yarns and Degree of Twine in the Thread Units. 102.—Weave Design in Worsted-Twist Manufactures. 103.—Warp-face Principle of Intertexture. 104.—Cotton and Linen Union Yarns and Natural Tinted Contrasts.

86. *The Ordinary Type of Union-Twist Threads.*—Twist yarns may be employed as a unit in the manufacture of a special grade of cloth, or as a structural feature in fabric design. Two and three-ply threads, when composed of wool and cotton, worsted and silk, etc., are largely used for the first function, though, as will be evident in the fuller analysis of their application, they also offer definite facilities in the origination of pattern style. Multi-ply, irregular, and " fancy " folded yarns, which do not at present come under consideration, have a primary utility in the development of textural newness, being decorative in effect and in colour composition and attributes.

The ordinary variety of union-twist is a folded yarn, plain in structure, and even in formation. Having a smooth surface, and being free from circumferential elements other than those due to twisting one thread with another, such twist yarns are adapted for cloth construction by similar practices as single-spun yarns, and folded yarns of a like material and counts. As a type of thread it is, however, to

be distinguished from the simple folded yarn, which is purely a compound of several single threads of a corresponding size and filament classification, as, for example, 2-fold 60's cotton, 2-fold 40's worsted, or 2-fold 30 skeins woollen. Here the thread ingredients combined are identical in quality and character, whereas, in union-twists, it is fundamental that the yarns folded together should differ in the fibrous substance of which they are formed, if not in diameter, turns per inch, and in system of production.

87. *Union Yarns a Basis of Textural Production.*—All such twist threads result in the weaving of a union manufacture in which the percentages of wool and cotton, worsted and silk, cotton and flax, and other varieties of spinnable fibre, are governed by the kind of compound yarn employed. The idea in the formation of the twist is to combine, in a fixed ratio, the fibrous factors of which the single threads are made, and this is done by the relative thicknesses of the two or more yarns twisted into one thread, or by their respective lengths and weights to the counts of the folded yarn on the lines developed in the examples of union twists on pages 19, 20, and 21. In this connection it should be observed that the true productive basis, in each branch of textile manufacture, is in the descriptions of yarn usable, and in their technical features and properties. The yarn unit defines the possibilities in looming, dyeing and finishing ; and it is in this relation that the subject of union twist threads has first to be considered. As regards union cloth fabrication, four phases of work are affected by the structural value and diversity of the sorts of yarn this method of compound thread construction provides, namely : (1) the latitude for the modification of the quantitative proportions of the different materials in the woven texture ; (2) the range in yarn counts, structure and qualities for warp and weft ; (3) the textural types, effects and combinations practicable ; and (4) cloth diversification as attained in manufacturing and finishing practice.

For showing how far these technical essentials are met,

and their bearing on progressive textile effort, by the yarns under analysis, reference will be made to the examples in union-twist threads specified in Table III. These are divided into nine typical groups, each denoted by the sort of yarn which constitutes the predominate class of fibre in the compound thread. Following this classification, each description of twist is quoted in the system of counting applicable to the distinctive quality of the folded yarn produced, as the woollen (with cotton) twists designated in skeins, the cotton (with woollen) in hanks, the linen (with cotton) in leas, and the worsted, cotton and silk twists in worsted hanks ; giving a method of folded union yarn nomenclature which acts as a guide to the material ingredients employed, and also to the plus filament unit in the twisted yarn.

88. *Twist Thread Structure and Manufacturing Latitude.*— The latitude for manufacturing differentiations in the fibres combined in the cloth in the use of union-twist yarns, may be judged from the specimens tabulated, which are not to be taken as complete but as representative of the assortment of fibre and of thread structures feasible, and also as illustrative of the varieties of such compound threads, and of their general applicability in textural construction and fabrication. Examining these yarns (Table III), it will be seen that in Group A, woollen and cotton twists, the percentage of wool varies from 52 to 67 ; and that in Group A′, cotton and woollen twists, the percentage of cotton fibre varies from 54 to 59. In the worsted and cotton units, Group B, the wool factor ranges from 54 to 67 per cent., and in the cotton and worsted units, Group B′, the cotton factor from 53 to 69 per cent. These percentages of wool and cotton by no means cover the ratios in which the two filaments may be combined in thread form, but they none the less present a series of twisted thread units which offer a diversified admixture of the materials in manufacturing work, and in which the amalgamation of the fibrous sorts is effected in the folding or twisting, as differing from their admixture in the processes of yarn spinning.

Relative to the other classes of twists comprised in the Table, it will be noted that in the cotton and linen, C, from 54 to 61 parts of the material in the yarns is cotton; and that in the linen and cotton threads, C′, flax forms from 55 to 62 parts of the constituent fibres. Here again the percentage of either cotton or flax may be raised by a modification in the counts of the individual yarns, and in agreement with a prescribed basis of fabric production. In combining silk with worsted, whether in two- or three-fold twisting, wool should be the dominant quantity of the material used in the formation of the composite yarn. Thus, in the examples given in Group D, wool forms from 60 to 76 parts of the filaments used. The same general rule is observed in twisting silk with cotton yarns, hence in series E about 57 to 74 per cent. of the material consists of cotton fibre. In respect to the three-fold twists,—worsted, cotton and silk, Group F—one principle of union-thread formation consists in the wool yarn being equal to approximately one-half of the material in the compound product, with the cotton representing one-third, and the silk the remaining one-sixth of the material factor, as in the twists Nos. 2 and 3. But when, as in certain styles of dress and light textures, the silk thread is required to impart a special tone to the fabric, the count of the worsted thread is proportionately changed, and also that of the cotton, which allows the silk ingredient to be accordingly increased, as shown in the examples 4 and 5, Group F.

89. *Paramount Material Factor in Union Twists.*—A fundamental feature in these union threads is that the woollen, worsted, cotton or flax is preferably made the paramount material quantity, and this gives to the manufactured cloth a corresponding filament character, moderated in degree by the percentage in which a particular class of fibre predominates in the two or three kinds of yarn twisted together. This provision, allied with the scale of proportions in which the fibres are blended in the several groups of twist thread units, renders variations in manufacturing practice possible in two

important directions. First, in the woollen or worsted and cotton twist yarns, the cloth produced may be of a woollen or worsted character ; and, second, in the cotton and woollen or worsted twist, the cloth may be made to possess more or less the quality of a cotton structure. Similarly in the cotton and linen, and in the linen and cotton threads—Groups C and C′, Table III—the fabric woven may partake of either a cotton or linen property and appearance, with the extent to which the cotton or the linen unit is the thicker and forms the bulk of the material in the twisted yarn. It is thus apparent that union-twist threads offer a wide field for manufacturing work, particularly as regards textural quality. Moreover, in the weft yarn employed in the cloths for which these threads are selected, there is, as will be exemplified, a further means of regulating and enlarging the range of percentages in which the fibrous ingredients are combinable in the manufactured goods.

90. *Structural Variations in Union Yarns.*—Diversity in yarn counts or diameter, and in yarn structure, are basic elements in union manufacture, inasmuch as they influence and control the relative material values in the woven fabric, and yield the grades and types of cloth producible. Union-twist threads satisfactorily answer to each of these conditions. As to structural character and textile features, they are susceptive to four schemes of modification : (*a*) by the degree of twine in the two or more yarns folded into one thread ; (*b*) by the direction of the twine in the initial yarns relative to the direction of the twine in the twisted yarn ; (*c*) by the respective counts of the single threads combined ; and (*d*) by the materials of which the several yarns folded together are composed. The productive advantages, acquired by these methods of changing the structure of union twists, are only to be adequately understood and appreciated by experimental study, but they will be dealt with and illustrated in treating of multi-ply union yarns and their applications.*

* See Chapter V, *Woollen and Worsted.*

91. *Manufacturing Provision in Union-Twist Counts.*—In forming a union-twist yarn basis, the textural applications of the yarns and the classes of woven manufactures intended have to be taken into account, and these factors have been provided for in the framing of the compound thread units specified in Table III. Thus, the first variety of yarn, or the woollen and cotton twist, is adapted for the production of fabrics of a similar thread compactness, or warp and weft setting, and weight per yard, as the standard makes of pure woollen cloths, both of a Saxony and Cheviot character, the nature of the material selected for the woollen thread in the twist coinciding with the quality of fabric required. All-wool manufactures comprise light costume and suiting textures, fabrics of a medium thickness, heavy builds of cloth, and coarse and open grades of production as in the lower classes of blankets and rugs. That is to say, in the first type of these manufactures, yarns are applied averaging from 20 to 32 yds. per dram, or such counts of union twists as defined in examples 1 to 5 in Group A. For the intermediate weights of fabric, twists Nos. 5, 6 and 7 are suitable, while for the heavier and also coarser structures, according to the system of looming adopted, the yarns enumerated at 9, 10 and 11 would be applied. Should finer or lower kinds of manufacture be requisitioned, union twists would be prepared of a smaller or increased diameter, adjusting the counts and filament composition of the yarn to the special sort of mixture to be fabricated. The second group of twists, A′, range from 1·6 to 6·6 cotton counts, or from practically 5 to 21 skeins woollen, and are, therefore, of appropriate diameters for similar but inferior goods as those for which yarns 4 to 11 in series A are employed. Though containing a higher percentage of cotton than wool fibre, they are still adapted for cloths made and finished on the woollen principle. They are preferred to the more woollen structure in manufactures needed rather for covering than for clothing purposes, and have, moreover, a value in the construction of domestic and decorative fabrics.

In the worsted industry, which also includes dress, costume, light and winter suitings, overcoating and certain species of tapestry cloths, the assortment of two-ply warp yarns does not ordinarily exceed the count limits represented in the twist threads in Group B. These range from 12's to 57's with the principal yarn sorts used in the bulk trade in worsted production, or such standard counts as 32's, 28's, 23's, 22's, 18's, 12's, 10's and 9's, and equal, for warp, to 2-fold 64's, 2-fold 56's, 2-fold 46's, 2-fold 36's, 2-fold 24's, 2-fold 20's, and 2-fold 18's. From which it will be understood that each style of worsted texture obtained in the latter yarns, could be imitated, as to yarn thickness, in the union twists tabulated. In addition, thin varieties of fabric, specially applicable to dress textures, are producible in the finer yarns quoted in Nos. 1 to 7 inclusive, and corresponding to 2-fold 115's, 2-fold 108's, 2-fold 96's, 2-fold 88's, 2-fold 80's, 2-fold 75's, and 2-fold 68's worsted. Moreover, for more substantial and heavier kinds of cloth, but of a like filament proportion as to wool and cotton, to the threads in Table III, the worsted counts may be graduated to 10's or 8's and the cotton counts to 12's or 10's.

As in the instance of twists A and A′, which were shown to be usable for corresponding classes of fabrication, so here, both twists B and B′ are suitable for the manufacture of fabrics of an equivalent weight per yard, and in the same schemes of looming—threads B′ yielding, however, cloths of the fuller cotton quality and of the more economic construction. This does not necessarily imply textures deteriorated in wearing strength and durability, but a perceptible change in their clothing properties, as evident in softness and warmth in the made-up garment. It should be noted that the lack of warmth in the use of this make of fabric, when the wearing value is satisfactory, is not prejudicial but favourable to its selection for South American markets, and also for clothing in warm and hot climates generally. Union twists B′ thus result in a type of manufacture for which yarns of a higher

woollen formation are neither so useful in gaining the textural effects, or so well-fitted for giving the textural qualities, desired in these branches of textile trading.

92. *Cotton and Linen Union Threads.*—When the thread units composed of cotton and linen are examined—Series C—they are found to comprise yarns ranging from 24's to 58's (= 2-fold 48's to 2-fold 116's cotton) rendering them applicable to different thicknesses and grades of fabric from the sheeting to the cambric. With flax as the excess fibre in the twist—threads C′—the counts are, on the average, raised, which has the effect of adding to the applicability of the yarns to the weaving of the thinner and better makes of linen unions. Threads 1, 2 and 3 are of a smallness of circumference (the same in hanks per lb. as 2-fold 88's, 2-fold 80's and 2-fold 68's cotton) to enable them to be employed for warp in the construction of fine gauze, leno and muslin textures. The fibrous proportions may, however, remain unaltered and lower counts of twist yarn obtained, but the textural results, in doing this. approach too closely those acquired in the medium thicknesses of twist in which cotton is the paramount factor.

93. *Silk Twist Yarns.*—Twist yarns,—Groups D, E and F—in which silk constitutes one of the thread units, have a number of special applications, being utilized in the manufacture of fancy as well as standardized classes of fabric. They need to be satisfactorily varied in counts and yet economically constructed as to the percentage of silk fibre used in the folded yarn. The examples—Series D, E and F—suggest the structural combinations favourable, being diversified in twist counts and well differentiated in regard to the size and type of worsted, cotton and silk threads combined. The twists in which 2-fold worsted or 2-fold cotton yarns are doubled with 2-fold silk make a firm, compact four-ply thread structure of high tensile property, and hence its employment—chiefly for warp—in the firmer makes of silk and wool or silk and cotton unions, such as dress, vesting and also decorative fabrics. On the other hand, the twists composed of single worsted or

cotton and silk, with the quantitative ratios of the two fibres modified—Nos. 4, 5, 6 and 7 D and Nos. 5, 6 and 7 E—are of a flexible, supple nature, which is conducive to their application to dress and blouse stuffs, or to textures where softness of feel is an essential. As to the counts' latitude, this is inclusive, in Group D, of yarns equal to 2-fold 54's, $^2/64$'s, $^2/72$'s, $^2/76$'s, $^2/86$'s, and 2-fold 128's worsted, and in Group E of yarns corresponding to 2-fold 40's, $^2/48$'s, $^2/60$'s, $^2/68$'s, and 2-fold 70's cotton. In the 3-fold examples, F, the silk unit is considerably reduced, with the formation of a twist yarn combining the qualities of wool, cotton and silk, and subjective if applied in the grey, to three systems of tinting in the dyeing of the goods. Here compound threads of approximate diameters to 2-fold 40's, $^2/48$'s, $^2/50$'s, $^2/56$'s, $^2/68$'s and 2-fold 70's worsted are represented, denoting that they are adapted to the manufacture of either the ordinary classes of fancy worsteds, or to special varieties of dress and vesting fabrics.

94. *The Productive Problem—Tabulated Examples.*—Having, as indicated, formulated and established a union-twist yarn scheme on an adequate filament basis for manufacturing purposes, and one in which the twists are correctly graded from threads of a convenient workable diameter to threads of an extreme fineness, the problems connected with the fabrication of standard types and qualities of cloth require to be examined, illustrated and dissected. It is proposed, in this connection, to treat of each variety of union-folded yarn in the order specified in Table III, for which schemes of manufacture will be stated in tabulated form. Commencing with the woollen and cotton twists—Series A and A′—examples in productive practice will be found in the two tables appended.

TABLE XV

Union-Twist Yarn (Wool and Cotton) Fabrics

	Examples.	Warp Yarn.	Ends per inch in Loom.	Width in Reed in inches.	Weft Yarn.	Picks per inch in Loom.	Length of Warp in yards.	Approx. Length of Piece Woven.	Approx. Length of Piece Finished.	†Weight per Yard in ozs. 54 in. wide.	Weave Plan.	Calculated Filament Composition of Fabric.
Fabrics A	.	No. 1 Twist, A, Table III	36	64	Same as Warp	34	60	56	54	8	Plain	67 % Wool, 33% Cotton
	II.	,, 1 ,, A ,,	42	66	*28 sks. $^{70W}/_{30C}$	40	,,	,,	,,	10	$\frac{1}{1}^{2}$ twill	69 ,, 31 ,,
	III.	,, 1 ,, A ,,	40	65	,, ,,	38	,,	,,	,,	9½	Fig. 73A	68 ,, 32 ,,
	IV.	,, 2 ,, A ,,	46	66	26 sks. $^{60W}/_{40C}$	46	,,	57	55	12	$\frac{2}{2}^{2}$ twill	62 ,, 38 ,,
	V.	,, 2 ,, A ,,	48	65	24 sks. ,,	44	,,	,,	,,	12½	$\frac{1}{1}^{3}$ twill	62 ,, 38 ,,
	VI.	,, 3 ,, A ,,	42	64	24 sks. ,,	42	,,	56	54	12½	Fig. 74D	62 ,, 38 ,,
	VII.	,, 3 ,, A ,,	44	65	22 sks. $^{70W}/_{30C}$	44	,,	,,	,,	14	$\frac{1}{1}^{3}$ twill	67 ,, 33 ,,
	VIII.	,, 4 ,, A ,,	40	67	20 sks. $^{80W}/_{20C}$	40	,,	57	55	15	$\frac{2}{2}^{2}$ twill	66 ,, 34 ,,
Fabrics B	IX.	No. 5 Twist, A, Table III	38	64	Same as Warp	36	60	56	54	14½	Fig. 75A	62% Wool, 38% Cotton
	X.	,, 5 ,, A ,,	36	68	18 sks. $^{75W}/_{25C}$	34	,,	,,	,,	15	$\frac{2}{2}^{2}$ twill	68 ,, 32 ,,
	XI.	,, 6 ,, A ,,	36	67	16 sks. $^{80W}/_{20C}$	38	,,	,,	,,	17	Fig. 74A	69 ,, 31 ,,
	XII.	,, 6 ,, A ,,	34	68	14 sks. $^{60W}/_{40C}$	32	,,	,,	,,	16½	$\frac{1}{1}^{3}$ twill	59 ,, 41 ,,
	XIII.	,, 7 ,, A ,,	32	67	15 sks. ,,	32	,,	,,	,,	16½	Fig. 74D	61 ,, 39 ,,
	XIV.	,, 7 ,, A ,,	32	68	14 sks. $^{70W}/_{30C}$	30	,,	,,	,,	16½	$\frac{2}{2}^{2}$ twill	66 ,, 34 ,,
Fabrics C	XV.	No. 8 Twist, A, Table III	28	70–76	11 sks. $^{65W}/_{35C}$	26	60	55	53	19–20	$\frac{2}{2}^{2}$ twill	62% Wool, 38% Cotton
	XVI.	,, 8 ,, A ,,	26	72–80	10 sks. ,,	28	,,	,,	,,	20–22	Fig. 74A	63 ,, 37 ,,
	XVII.	,, 9 ,, A ,,	26	70–74	9 sks. $^{80W}/_{20C}$	24	,,	,,	,,	20–21	$\frac{2}{2}^{2}$ mat	67 ,, 33 ,,
	XVIII.	,, 9 ,, A ,,	24	72–78	,, ,,	22	,,	,,	,,	19½–21	$\frac{1}{1}^{3}$ twill	67 ,, 33 ,,
	XIX.	,, 10 ,, A ,,	21	70–78	7 sks. $^{60W}/_{40C}$	18	,,	,,	,,	20–22	$\frac{2}{2}^{2}$ twill	59 ,, 41 ,,
	XX.	,, 10 ,, A ,,	18	72–80	5 sks. ,,	16	,,	,,	,,	22–24½	,,	59 ,, 41 ,,

* Bi-fibred woollen, 70% wool, 30% cotton. † Less loss in finishing, 15%.

TABLE XVI

Union-Twist Yarn (Cotton and Wool) Fabrics

	Examples.	Warp Yarn.	Ends per Inch in Loom.	Width in Reed in Inches.	Weft Yarn.	Picks per Inch in Loom.	Length of Warp in Yards.	Approx. Length of Piece Woven.	Approx. Length of Piece Finished.	†Weight per Yard in Ozs. 54 in. wide.	Weave Plan.	Calculated Filament Composition of Fabric.
Fabrics A	I.	No. 1 Twist, A′, Table III	28	64	*12 sks. $^{65W}/_{35C}$	26	60	56	54	12½	$\frac{1}{2}^2$ twill	57% Wool, 43% Cotton
	II.	„ 2 „ A′ „	22	66	10 sks. $^{75W}/_{25C}$	22	60	„	„	12½	Fig. 73A	63 „ 37 „
	III.	„ 3 „ A′ „	26	65	10 sks. $^{60W}/_{40C}$	26	„	„	„	15	$\frac{1}{3}^2$ twill	55 „ 45 „
	IV.	„ 3 „ A′ „	26	64	9 sks. $^{80W}/_{20C}$	24	„	55	53	15	$\frac{2}{2}^2$ twill	67 „ 33 „
	V.	„ 4 „ A′ „	25	66	8 sks. „	23	„	„	„	17	$\frac{2}{2}^2$ mat	66 „ 34 „
	VI.	„ 5 „ A′ „	21	65	7 sks. $^{70W}/_{30C}$	19	„	„	„	15½	$\frac{2}{2}^2$ twill	61 „ 39 „
Fabrics B	VII.	No. 6 Twist, A′, Table III	18	72	8 sks. $^{80W}/_{20C}$	18	60	55	52	16	Plain	63% Wool, 37% Cotton
	VIII.	„ 7 „ A′ „	21	68	6½ sks. $^{75W}/_{25C}$	19	„	„	„	19½	$\frac{2}{2}^2$ twill	62 „ 38 „
	IX.	„ 8 „ A′ „	18	68	5 sks. $^{60W}/_{40C}$	18	„	„	„	22½	$\frac{1}{3}^2$ twill	54 „ 46 „
	X.	„ 8 „ A′ „	18	70	5 sks. $^{70W}/_{30C}$	18	„	„	„	23	$\frac{2}{2}^2$ mat	61 „ 39 „
	XI.	„ 9 „ A′ „	16	68	4 sks. $^{65W}/_{35C}$	14	„	„	„	22½	$\frac{2}{2}^2$ twill	57 „ 43 „
	XII.	„ 9 „ A′ „	14	70	3 sks. $^{65W}/_{35C}$	12	„	„	„	24	$\frac{2}{2}^2$ twill	58 „ 42 „

* Bi-fibred woollen, 65% wool, 35% cotton. † Less loss in finishing, 15%.

95. *Weft Thread—Filament Composition.*—In the foregoing tables it will be noted that, in addition to the setting, the weight per yard, and the counts of the warp and weft yarns, the percentages of wool and cotton, as calculated from the yarn

FIG. 72A

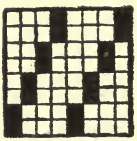


FIG. 72B

FIG. 72C

FIG. 73A

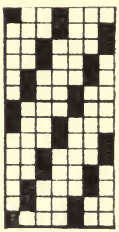


FIG. 73B

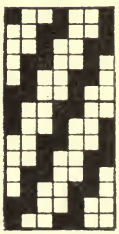


FIG. 73C

FIG. 73D

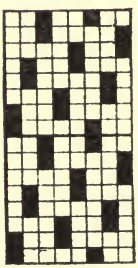


FIG. 73E

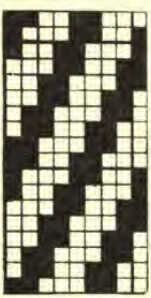


FIG. 73F

units, are also given. The influence of the weft factor is, therefore, seen in modifying the filament composition of the cloth in each example. It may, obviously, be made to either raise or lower the wool ingredient of the piece, but, as a rule, it is designed to attain the former result, both in union woollen and worsted manufacturing. Further, it is intended to

impart to the textures a fuller and softer handle than is obtainable in goods produced from twist yarns of this description. As they are two-ply threads, they have a tendency to yield cloths somewhat harsh to the feel. This feature may be moderated by the kind of weft yarn selected. Thus, examples I and II, Table XV, would differ perceptibly in this characteristic, for I would be the finer and harder, and II the more supple and flexible cloth. The twists employed would be equally effective in both textures, especially if consisting of woollen and cotton threads differing in shade or colour, but the bi-fibred woollen weft, in the latter, would cause this fabric to possess a fuller quality of softness and flexibility than the twist weft in the former. Increasing the counts of warp and weft, and changing the constituent threads in the twist, as in examples IX and X, only further differentiates the two grades of manufacture.

With a single yarn for weft, it is practicable to have this loosely spun, whereas in the twist weft, though the compound yarn is modifiable in a degree by the turns per inch in the single threads combined, yet it is structurally firm, compact, and unyielding. These respective properties of the two yarns are considered in the reed setting of the pieces, the single-weft cloths allowing of the freer width construction in milling than the two-ply weft cloths. To refer further to the latter examples, Piece IX is set 64″ as compared with Piece X 68″ in the loom, which is principally accounted for by the higher felting property the 18 skeins weft provides as contrasted with the woollen and cotton twist weft in the first make of fabric. When milling is an essential in manufacturing work—Fabrics C—the weft yarn should be invariably soft spun, and also regulated in the proportionate quantities of wool and cotton relative to the measure of felting to be induced and the quality of the animal fibre used.

96. *Qualities of the Weft Yarn.*—Whatever the class of manufacture—woollen and cotton, worsted and cotton, worsted and silk, cotton and linen, worsted, cotton and silk—

the weft yarn should, as a general rule, be (1) slightly thicker in counts than the twist yarn in the warp; (2) relatively loosely spun; and (3) of a fibrous consistency which will supplement the textural qualities of softness and adaptability in the wear derivable from the structure of twist thread utilized. The two-fold yarn is to be regarded as paramount in delineating the surface features of the fabric, and the weft yarn as primary in supplying elasticity and suppleness of handle to

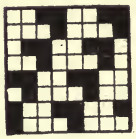


FIG. 74A

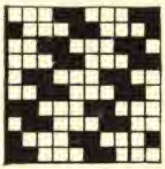


FIG. 74B

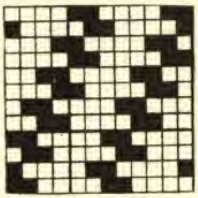


FIG. 74C

FIG. 74D

FIG. 74E

FIG. 74F

the finish cloth. A study of the tabulated examples will show that these technicalities have been strictly observed in framing the productive plans illustrated.

97. *Methods of Applying Two- and Three-fold Threads.*— Union twist yarns, being two- or three-fold and made of two or three kinds of fibre, are usable in the grey or in two or three colours. If applied in the natural state, the pieces would require, in the instance of each thread being differently tinted, to be dyed either in a compound bath, or in three processes. Should the twists in groups A or A′, Table III,

be employed, the cloth would be both cotton and wool dyed, when each thread could be matched approximately in the same shade; or the cotton thread, in the twist, be a distinct colour from that of the woollen thread. Taking the first arrangement, for the purpose of producing the fine twilled cloth, Ex. II, Table XV, in one colour, such as light brown, the piece would be woven in the warp and weft particulars stated, scoured, felted, washed-off, tentered and dried, and blown with steam prior to dyeing. Here the two yarns in the twist would be similarly tinted, following by washing-off and rinsing, re-tentering, cutting and pressing. The cotton yarn in the twist, and the cotton fibre in the union woollen weft, would, by reason of the lower colourization value of the cotton than the wool fibre, take a slightly duller hue than the latter, but the fabric would be of a uniform shade tone. In the second place, for developing the thread units in the two-fold yarn in different colours, two methods are practicable : first, that of dyeing the wool fibre in the cloth, say, black, leaving the cotton in the white, and resulting in the twist warp,—composed of black and white ends, Ex. II—and in the bi-fibred weft—70 per cent. wool and 30 per cent. cotton—taking a dark grey shade ; second, that consisting in dyeing—*e.g.*, brown and lavender—the wool and the cotton in the piece in separate processes, producing the twist yarn in these colours, and the weft yarn in a mixed shade formed of 70 parts of brown and 30 parts of cotton.

Another principle of manufacture is that of preparing the twist yarns in the colours they are intended to exhibit in the finished fabric. In illustration of this practice, it may be supposed that the $\frac{2}{2}$ twill cloth, Ex. IV, is to be obtained, and that the twist, No. 2 A, is made of green woollen and light olive cotton threads. Any suitable dark shade of yarn might be employed as weft, but if the idea should be to use a corresponding coloured weft as warp, this would be acquired by blending 60 parts (green) of wool with 40 parts (light olive) cotton in the spinning of the 26 skeins yarn specified for

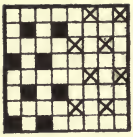


FIG. 75A

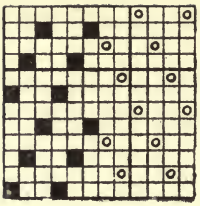


FIG. 75B

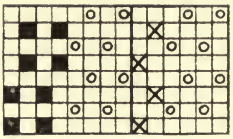


FIG. 75C

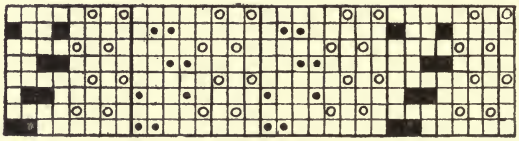


FIG. 75D

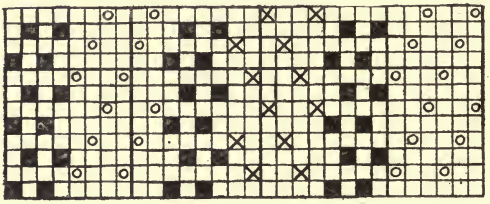


FIG. 75E

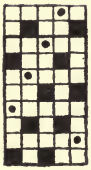


FIG. 76A

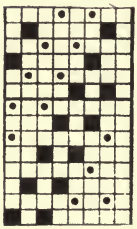


FIG. 76B

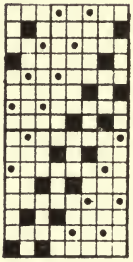


FIG. 76C

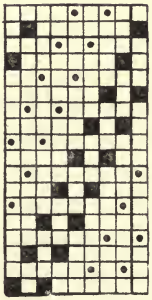


FIG. 76D

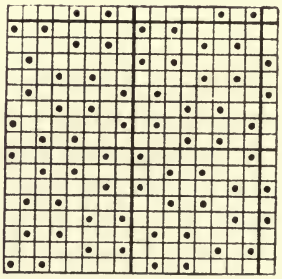


FIG. 76E

shuttling this cloth. By this practice, however, a number of mixture shades are preparable for weft, increasing the diversity of tinting in the fabric. Retaining the twist in the two colours stated, and crossing the warp with a weft formed of dark blue (wool ingredient) and of light fawn (cotton) the texture would contain four tints or be a mixture, in the warp, of 63 per cent. of green and 37 per cent of light olive (see No. 2A, Table III); and, in the weft of 60 per cent. of dark blue, and 40 per cent. of fawn (see Weft IV, Table XV). The weave being common twill and the weft a little thicker in counts—Ex. IV—than the warp thread, the tinting of the former would be equally present in the fabric with that of the latter, though the twist yarn structure would distribute the colour elements more evenly and visibly than the intermingled quality of the bi-fibred woollen yarn.

The construction of the union twist in the shades in which it is to be used in the cloth has, clearly, an advantage over the construction of this yarn in the grey in respect to the colour treatment of these manufactures. For costume and covert coating and other textures, in which a modicum of tinting is practised, the application of the twist yarn in the grey is satisfactory, especially as it is less restrictive as to the filament ratios adapted in the production of the weft thread. But for cloths in which colour tone and variation are important, the twists should be preferably made in the colours they are desired to be arranged in the warp of the piece.

98. *Weave Elements and Twist-Yarn Goods.*—The formation and character of union twist threads result in certain textural features not actually obtainable in single yarns, such as the regular distribution and demarcation of the particles of colour, of which they are composed, on the surface of the fabric, and which the weave plan should leave clear and distinct. The ordinary varieties of twill, mat and similar makes, are all useful as seen from the examples in the tables for the production of these fabrics; but in addition to such principles of interlacing, warp twills, whipcords, ribs, ribbed twills, and

crêpe effects, are also selected as being suitable for developing the details due to the qualities of the twist yarns. Illustrations of several typical groups of these special weaves are supplied in Figs. 72, 73, 74, 75, 76, 77 and 78. The three plans in Figs. 72A, B and C, prunelle, $\frac{3}{1}$ and $\frac{2}{2}$ twills, with the

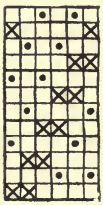


FIG. 77A

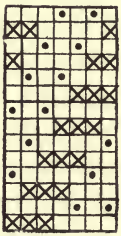


FIG. 77B

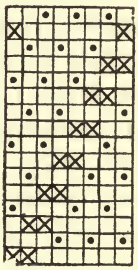


FIG. 77C

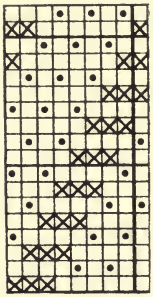


FIG. 77D

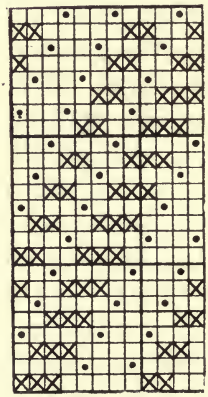


FIG. 77E

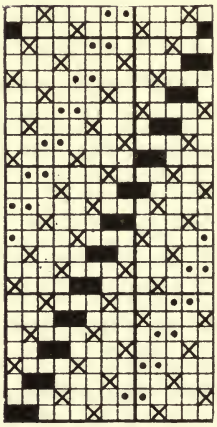


FIG. 77F

picks grouped in pairs, are mainly combined in striped patterns, and with weaves in which the picks move normally. The series represented in Fig. 73, A to E, include the 5- and 7-end Venetian, A and B; the 7-shaft upright twill, C; the 8-shaft fine line twill, D; the buckskin, E (also constructed on ten threads and picks), and the well-defined 9-end twill, F. Whipcord twills, on 4, 5, 6, 7 and 9 heddles are shown in Figs. 74,

A to E, and plain and striped ribs at Figs. 75, A to E. These different forms of warp and weft interlacing are applied in the fabrication of woollen and cotton, and worsted and cotton yarn unions, but the more open and varied in structure the weave unit, the less its applicability to the former cloths, and the greater its restriction in the manufacture of cloths consisting of the thicker counts of yarn. The twilled ribs in Fig. 76, A to E, are better suited for union-worsted than union-woollen twist productions, but the smaller of these crossings, such as Figs. 76, A to B, and also the weft-characterized ribbed twills, Figs. 77 A, B and C, may also be employed in the weaving of special grades of woollen and cotton twist fabrics.

Ribbed weaves, striped or twilled, of the classes illustrated in Fig. 75, B, C, D and E, and in Fig. 76, C, D, and E, are utilized to some extent in the higher counts of woollen and cotton yarns, with the cloths well set in the reed, and woven with a soft spun weft thread. Each weave type has a distinctive textural effect, Fig. 75 B forming a ribbed prunelle twill stripe, Fig. 75 C a cord and plain rib pattern, Fig. 75 D successive lines in cassimere and rib, and Fig. 75 E an angled small twill and ribbed design. An additional detail obtains in the plans, Figs. 77, A to F, as compared with the ribbed twills in Figs. 76, A, B and C, the weft yarn showing distinctly in the cloth, and producing, with the ribbed sections in the weaves, alternate twilled lines developed in the twist warp and in the yarn used in the shuttling. Arranging the plan as in Fig. 77F, makes it practicable to weave the twills, marked in ■'s and in ⊠'s in two shades of weft. Applying for example, this plan to the setting in Ex. VII, Table XV, and using the twist No. 3 obtained by folding a 40-skein medium brown with a 20's light tan cotton, and wefting one pick medium green and one pick pale blue, would give the dotted sections in the design in the colouring of the warp, and the two weft-twill sections in green and blue.

The crêpe weaves—Fig. 78, A to E—are chiefly applied in the manufacture of the thinner varieties of dress and blouse

materials, whether made of worsted and cotton or of worsted and silk union yarns. They are specially suited for producing a soft quality of texture intermingled in tinted composition; and, being frequent in the warp and weft intersections—almost

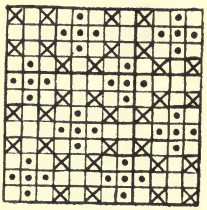


FIG. 78A

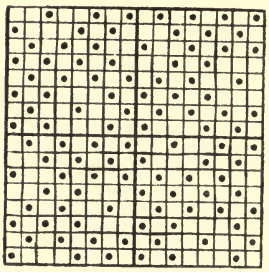


FIG. 78B

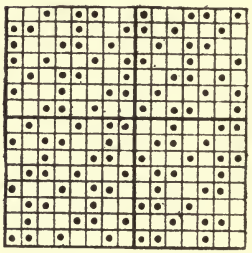


FIG. 78C

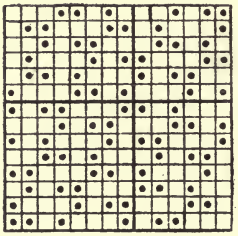


FIG. 78D

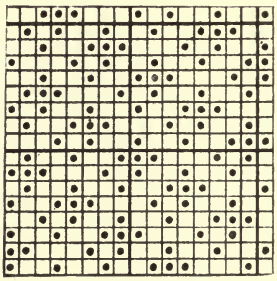


FIG. 78E

plain—they enable fine counts of yarn to be used with the production of an even woven structure.

99. *Union-Twist Yarn Fabrics—Tables.*—Suggestions in systems of textural construction, in which union worsted and cotton twists are employed, and to which the weaves described are applicable, are particularized in Tables XVII and XVIII, pages 139 and 140.

TABLE XVII

Union-Twist Yarn (Worsted and Cotton) Fabrics

	Examples.	Warp Yarn.	Ends per Inch in Loom.	Width in Reed in Inches.	Weft Yarn.	Picks per Inch in Loom.	*Weight per Yard in Ozs. 54 in. wide.	Weave Plan.	Calculated Filament Composition of Fabric.
Fabrics A.—Worsted and Cotton Twist.	I.	No. 1 Twist, B, Table III	90	60	Weft as Warp	84	$5\frac{1}{4}$	Plain	57% Wool, 43% Cotton
	II.	„ 2 „ B „	80	60	50's Bi-fibred Worsted $^{80W}/_{20C}$	76	$5\frac{1}{4}$	Fig. 78A	67 „ 33 „
	III.	„ 3 „ B „	78	60	44's „ „ $^{70W}/_{30C}$	72	$5\frac{1}{2}$	Fig. 78B	65 „ 35 „
	IV.	„ 4 „ B „	84	62	40's „ „ $^{75W}/_{25C}$	80	7	$\frac{1}{1}{}^{2}$ twill	65 „ 35 „
	V.	„ 5 „ B „	90	64	36's „ „ „	85	$8\frac{1}{2}$	Fig. 75A	67 „ 33 „
	VI.	„ 6 „ B „	72	63	40's „ „ $^{60W}/_{40C}$	72	$6\frac{3}{4}$	Fig. 73A	57 „ 43 „
	VII.	„ 7 „ B „	76	62	34's „ „ $^{75W}/_{25C}$	78	8	Fig. 76A	66 „ 34 „
	VIII.	„ 8 „ B „	70	62	30's „ „ $^{65W}/_{35C}$	66	8	$\frac{1}{1}{}^{2}$ twill	60 „ 40 „
	IX.	„ 9 „ B „	72	63	28's „ „ $^{70W}/_{30C}$	68	$8\frac{3}{4}$	$\frac{2}{2}{}^{2}$ twill	64 „ 36 „
	X.	„ 10 „ B „	70	63	26's „ „ $^{60W}/_{40C}$	66	9	Fig. 73C	59 „ 41 „
Fabrics B.—Cotton and Worsted Twist.	I.	No. 1 Twist, B′ Table III	88	62	48's Bi-fibred Worsted $^{70W}/_{30C}$	86	$6\frac{1}{4}$	$\frac{1}{1}{}^{2}$ twill	57% Wool, 43% Cotton
	II.	„ 2 „ B′ „	82	63	45's „ „ $^{80W}/_{20C}$	75	$6\frac{1}{4}$	Fig. 73A	64 „ 36 „
	III.	„ 3 „ B′ „	90	62	42's „ „ $^{60W}/_{40C}$	96	$7\frac{3}{4}$	Fig. 77B	51 „ 49 „
	IV.	„ 4 „ B′ „	84	62	40's „ „ $^{75W}/_{25C}$	90	$7\frac{1}{2}$	Fig. 77A	59 „ 41 „
	V.	„ 5 „ B′ „	90	63	32's „ „ $^{65W}/_{35C}$	86	$9\frac{3}{4}$	Fig. 74E	54 „ 46 „
	VI.	„ 6 „ B′ „	80	63	30's „ „ $^{70W}/_{30C}$	76	9	Fig. 74F	58 „ 42 „
	VII.	„ 7 „ B′ „	84	63	27's „ „ $^{60W}/_{40C}$	84	$11\frac{1}{4}$	Fig. 74C	49 „ 51 „
	VIII.	„ 8 „ B′ „	68	62	25's „ „ $^{75W}/_{25C}$	68	$9\frac{1}{2}$	Fig. 73C	63 „ 37 „
	IX.	„ 9 „ B′ „	62	63	20's „ „ $^{80W}/_{20C}$	60	11	$\frac{2}{2}{}^{2}$twill	56 „ 44 „
	X.	„ 10 „ B′ „	60	62	18's „ „ $^{60W}/_{40C}$	60	$11\frac{3}{4}$	Fig. 75C	49 „ 51 „
	XI.	„ 11 „ B′ „	58	64	15's „ „ $^{80W}/_{20C}$	58	14	Fig. 77D	56 „ 44 „
	XII.	„ 12 „ B′ „	52	64	14's „ „ $^{75W}/_{25C}$	48	13	$\frac{2}{2}{}^{2}$ twill	54 „ 46 „

* Length of Warp, 60 yards. Length of Piece Woven, 57 yards. Length of Piece Finished, 55 yards. Loss in Finishing, 5%.

TABLE XVIII

Union-Twist Yarn (Worsted and Silk, and Cotton and Silk) Fabrics

Examples.	Warp Yarn.	Ends per Inch. in Loom.	Width in Reed in Inches.	Weft Yarn.	Picks per Inch in Loom.	*Weight per Yard in Ozs. 54 in. wide.	Weave Plan.	Calculated Filament Composition of Fabric.
Fabrics A. Worsted and Silk Twist Warp.								
I.	No. 1 Twist, D, Table III	74	62	32's Bi-fibred Worsted $^{80W}/_{20C}$	70	$7\frac{1}{16}$	$\frac{1}{1}{}^{2}$ twill	70% Wool, 10% Cotton, 20% Silk
II.	,, 2 ,, D ,,	64	63	34's ,, ,, $^{75W}/_{25C}$	60	7	Fig. 73A	69 ,, $11\frac{1}{2}$,, $19\frac{1}{2}$,,
III.	,, 3 ,, D ,,	72	62	30's ,, ,, $^{70W}/_{30C}$	66	$8\frac{1}{2}$	Fig. 73C	70 ,, $13\frac{1}{2}$,, $16\frac{1}{2}$,,
IV.	,, 4 ,, D ,,	96	60	60's ,, ,, $^{75W}/_{25C}$	92	$5\frac{1}{4}$	Fig. 78A	70 ,, 12 ,, 18 ,,
V.	,, 5 ,, D ,,	84	60	50's ,, ,, $^{65W}/_{35C}$	84	$5\frac{1}{2}$	Fig. 78B	67 ,, 18 ,, 15 ,,
VI.	,, 6 ,, D ,,	76	61	40's ,, ,, $^{70W}/_{30C}$	72	$6\frac{1}{4}$	Fig. 78C	71 ,, 15 ,, 14 ,,
VII.	,, 7 ,, D ,,	68	61	36's ,, ,, $^{65W}/_{35C}$	66	$6\frac{1}{2}$	Fig. 78D	71 ,, 17 ,, 12 ,,
Fabrics B. Cotton and Silk Twist Warp.								
I.	No. 1 Twist, E Table III	72	61	31's Bi-fibred Worsted $^{60W}/_{40C}$	68	$6\frac{1}{4}$	$\frac{1}{1}{}^{2}$ twill	36% Wool, 47% Cotton, 17% Silk
II.	,, 2 ,, E ,,	64	60	28's ,, ,, $^{80W}/_{20C}$	58	6	Plain	47 ,, 37 ,, 16 ,,
III.	,, 3 ,, E ,,	64	62	22's ,, ,, $^{75W}/_{25C}$	60	8	$\frac{2}{2}{}^{2}$ twill	45 ,, 39 ,, 16 ,,
IV.	,, 4 ,, E ,,	72	61	19's ,, ,, $^{60W}/_{40C}$	68	$10\frac{1}{2}$	Fig. 74D	35 ,, 51 ,, 14 ,,
V.	,, 5 ,, E ,,	68	60	38's ,, ,, $^{70W}/_{30C}$	64	5	Fig. 78A	41 ,, 45 ,, 14 ,,
VI.	,, 6 ,, E ,,	62	60	34's ,, ,, $^{80W}/_{20C}$	60	5	Fig. 78B	47 ,, 41 ,, 12 ,,
VII.	,, 7 ,, E ,,	58	60	28's ,, ,, $^{75W}/_{25C}$	58	$5\frac{3}{4}$	Fig. 78C	46 ,, 45 ,, 9 ,,
Fabrics C. Worsted Cotton and Silk Twist Warp.								
I.	No. 1 Twist, F, Table III	64	62	28's Bi-fibred Worsted $^{70W}/_{30C}$	60	$7\frac{3}{4}$	Fig. 73A	59% Wool, 31% Cotton, 10% Silk
II.	,, 2 ,, F ,,	58	62	24's ,, ,, ,,	56	$8\frac{1}{4}$	,,	60 ,, 32 ,, 8 ,,
III.	,, 3 ,, F ,,	52	62	18's ,, ,, ,,	50	$9\frac{3}{4}$	,,	60 ,, 32 ,, 8 ,,
IV.	,, 4 ,, F ,,	70	61	32's ,, ,, $^{60W}/_{40C}$	74	$7\frac{1}{2}$	Fig. 77A	53 ,, 35 ,, 12 ,,
V.	,, 5 ,, F ,,	68	61	26's ,, ,, $^{50W}/_{50C}$	72	9	Fig. 78A	50 ,, 40 ,, 10 ,,
VI.	,, 6 ,, F ,,	56	61	22's ,, ,, ,,	52	8	$\frac{1}{1}{}^{2}$ twill	50 ,, 39 ,, 11 ,,

* Warp length, 60 yards. Approximate length of Piece, 57 yards. Finished Piece length, 55 yards. Loss in Finishing, 5%

100. *Worsted Union-Twist Textures.*—These data may be taken as illustrative of the diversified classes of fabric producible in worsted union twist yarns, more particularly when such yarns are employed in the warp, and woven with a bi-fibred worsted weft. The use of twist threads, for shuttling as well as for warp, has the effect of making a crisp-handling texture, but one in which the colour details are fully intermingled, and also distinguished by clearness of tone. A standard type of thin, light fabric is obtainable by selecting two or more sorts of coloured twist yarns and arranging them in some simple looming order. Constructing Ex. III, Table XVII, on this system, the yarns might, for instance, be grouped in the warp one-and-one, two-and-one, and three, one, two and one, combining two varieties of the twist thread 3 B, Table III, namely, thread 1 formed of black worsted and an intermediate shade of cotton, and thread 2 formed of a dark shade of worsted and of a light tint of cotton. The weft yarns would be either composed of the same or dissimilar colours to the warp yarns, and follow the same order in weaving as the warping plan. This style of combination and texture is preferably produced in crêpe, fine rib, and plain weaves in the thinner groups of cloth, but it is also a useful scheme of manufacture in medium weights of fabric, when weaves of the $\frac{2}{2}$ twill character are applicable.

101. *Compound Yarns and Degree of Twine in the Thread Units.*—The degree of twine in each of the threads in the twist yarn, in the production of the thinner makes of fabric in which the weft is a single-spun bi-fibred worsted, is a factor to be determined by experimental work in the formation of the two-ply yarn relative to textural build and quality. Twine differentiation is valuable in modifying the softness and flexibility of the woven structure. A basic principle obtaining in the preparation of this yarn is, the firmer the twine in the thread units of which it is made, the harsher and more resisting the feel of the cloth. By reducing, in the twisting process, the turns per inch in the threads folded into one, the supple

nature of the compound or twist yarn is enhanced, and a more cohesive relation of the filaments, in the respective threads, is induced. To supplement the initial twine of one of the threads, in the folding operation, and not that of the other,

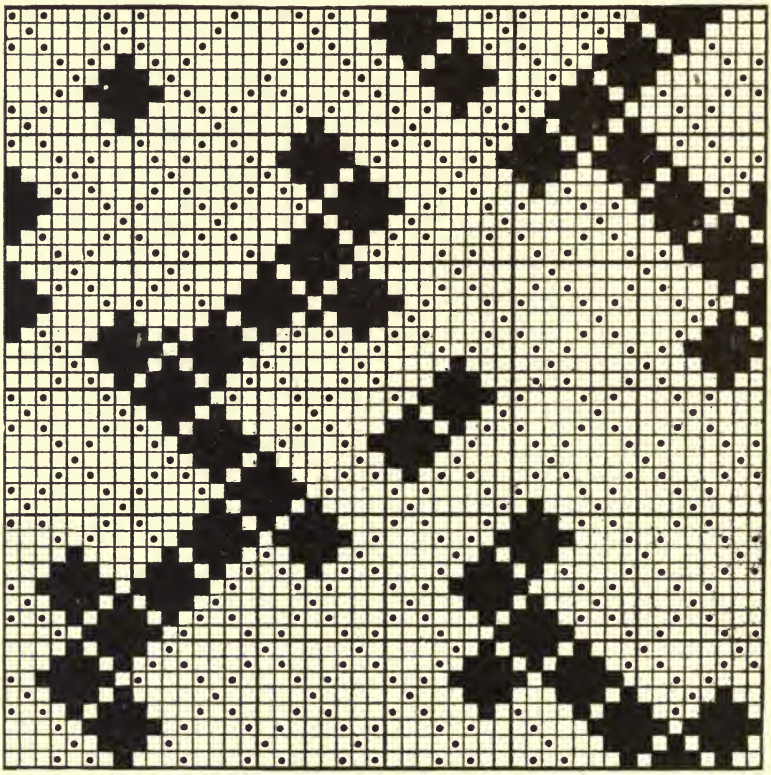


FIG. 79

causes the thread thus affected to appear unduly attenuated and to be apparently diminished in thickness ; while the thread or threads unaffected present, in the twisted yarn, a looser and fuller fibre consistency than that actually represented by the normal diameter or counts. These technicalities in making union twists are to be understood as exercising a controlling effect on the tensility, suppleness, and smoothness

of the finer qualities of fabric in which they are used either as warp or as warp and weft.

102. *Weave Design in Worsted-Twist Manufactures.*—In the first series of examples, A, Table XVII, the full range of worsted and cotton twists specified in Table III is not illustrated; but the types of manufacture in the second series, Fabrics B, include, in the settings Nos. 8 to 12, the intermediate kinds of cloth, which settings are also applicable to yarns B. It will be observed that the weave element is more varied than in the examples in Tables XV and XVI, and that the textures are graded from a small number to over 14 oz. per yard, 54 in. wide. The single-make scheme of intertexture is followed in the construction of each quality of fabric comprised. For making heavier descriptions of cloth than those instanced, one method obtains in the employment of thicker counts of twist yarn, and a second method in substituting a union woollen weft for the bi-fibred worsted weft, which involves setting the pieces wider in the loom, and supplementing the net weight per yard of the fabric by width shrinkage, as in the range of cloths specified in Examples C, Table XV.

103. *Warp-face Principle of Intertexture.*—Strictly in these fabrics—Tables XVII and XVIII—similar classes of textural design may be practised as in the construction of solid worsteds made in corresponding counts of yarn. A technicality to be understood is, however, the value of weave in emphasizing the two-ply structure of the twist thread, especially when this is used in the warp of the fabric. From the plans and weave combinations in Figs. 72 to 78, it will be seen that the warp-face principle of intersection is chiefly utilized. An even, regular build of cloth is essential, and for this purpose, and also for the correct demarcation of the twist features, the ribbed plan of weave is well adapted. It is combinable in twill, striped and diagonal form, and affords considerable scope for pattern variation. Moreover, for the ordinary twist yarn counts, such as those approximating 14 to 26 hanks per lb., and systems of setting averaging from

44 to 80 ends per inch, the elementary types of weaves, and their derivative structures, being usable, they add to the designing facilities available in these manufactures.

104. *Cotton and Linen Union Yarns and Natural Tinted Contrasts.*—The cotton and linen twist yarn fabrics, while not variable in the same manner, or to a like extent, by tinting practice as the groups of fabrics exemplified in Tables XV to XVIII, offer another textural property, that of tone contrast in the natural colour of the two fibres. Under certain looming conditions this property may be utilized in the origination

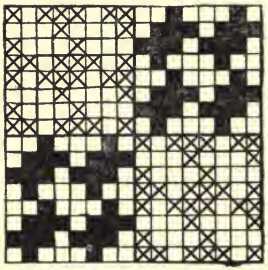


FIG. 80

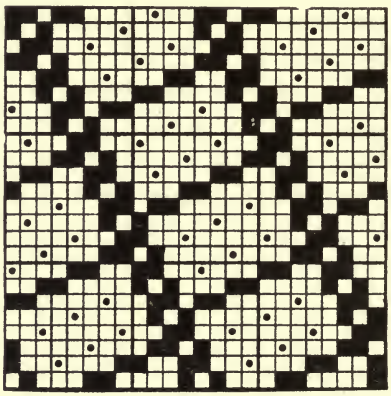


FIG. 81

of distinctive grades of fabrication. The weave design is important and should be devised to emphasize the respective tinted qualities of the flax and cotton, and also the formation of the twist yarn in the warp as differing from the softer nature of cotton yarn applied in the weft. Assuming, for example, the twists Nos. 2, 3 and 4, C, Table III, to be used in the warping, and 50's, 44's, and 40's cotton in the wefting, in the weaving of textures in the designs in Figs. 79, 80 and 81, the effects and structure of the two kinds of yarn would be suitably accentuated. The diamond elements, printed in blank □'s in Fig. 79 would, by this arrangement, be expressed, in the fabric, in the pale straw-coloured linen and white cotton

twist, and the parts shown in black ■'s would be woven in the 50's pure white cotton. Fig. 80 would develop the serial details in □'s in the twist thread, and the transposed serial details in ■'s in the single 44's cotton, attaining a clear definition of the checked style, typical of the precise form of pattern delineation obtainable in inverted weave elements; and, in the natural tinted contrasts of the flax and cotton fibre, rendered increasingly effective by one of the yarns in the texture being of the union-twist variety. The intersected diagonal, Fig. 81, admits of the sateen ground being woven in the twisted warp thread, and of the twilled lines in the cotton weft, or of the former being produced in straw and white tints, and of the latter being formed in floats of pure white yarn. In this, and similar design principles, the changing of the direction of the sateen twill so that it is the reverse of that of the twine movement in the two-fold warp thread, assists in defining the structure of the cotton-and-linen twist yarn, and of the features it develops in the cloth.

Other schemes of production, in which the cotton end in the twist is dyed a particular colour, provide technicalities which result in artificially tinted fabrics, and these will need to be specially illustrated.

CHAPTER VI

TEXTURAL STUDIES

105.—The Object and Scope of the Studies. 106.—Covert Coating and Twilled Textures. 107.—Typical Specimens Analysed. 108.—Single and Backed Structures. 109.—Contrasts betwixt Single and Twist Yarn Textural Features. 110.—Interchanging of the Counts of the Thread Units. 111.—Limitations in "Count" Differentiations. 112.—Equalization of Fabric Quality in Broad Striped Patterns. 113.—Twists, Single-quality, and Bi-fibred Yarns Combined. 114.—Specimens in Multi-quality Yarns. 115.—A Checked Example. 116.—Patterns with Light-coloured Grounds. 117.—Variations in the Diameters of the Single-thread Units. 118.—Bi-fibred Yarns and Twist Threads. 119.—Union-Worsted Twist and Union-Worsted Yarn Fabrics. 120.—Patterns with Dark-toned Grounds. 121.—Utility of Double-make Cloths in Yarn Distribution. 122.—Compound Checking in Yarns of Different Structures. 123.—Linen and Cotton-Twist Unions.

105. *The Object and Scope of the Studies.*—One object of the studies proposed is to make it clear how certain pattern styles, ordinarily obtainable in woollen and worsted yarns, and produced in coloured warp and weft threads, may be closely imitated in union-twist and bi-fibred yarn structures. A second object is to define in greater detail the yarn construction, composition, and thread grouping in these manufactures, when the intention is to dye the piece, weaving the fabrics in the grey.

Studies, in single and various schemes of intertexture, will be dealt with, and also in cloths with a preponderating cotton or wool ingredient. Flax and cotton specimens, in which union yarns are used, will, in addition, be treated of; but it is understood that, in respect to dyeing treatment in the woven state, these productions do not belong to the same category as cloths composed of fibres showing a different chemical analysis, and having distinctive affinities for colouring matters.

Fabrics, in which two-ply yarns form either the warp or weft, or both warp and weft, are chiefly implied, with the

employment of bi-fibred yarn, and yarn of one material quality, for acquiring definite textural features and effects. Still, in all instances to which reference will be made, the cloths consist largely of the union description of twist yarn, such as

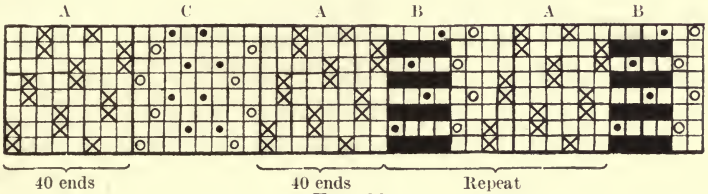


FIG. 82

FIG. 83

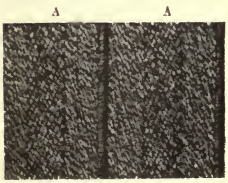


FIG. 82A

FIG. 84

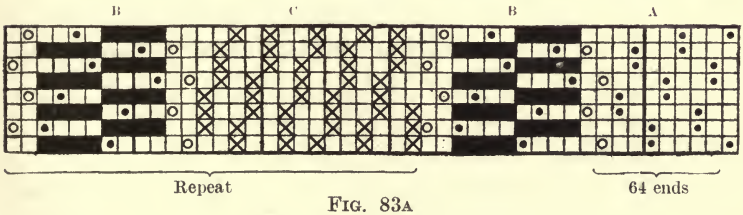


FIG. 83A

woollen and cotton, worsted and cotton, worsted and silk, and linen and cotton.

106. *Covert Coating and Twilled Textures.*—Considering the principles of work as they apply, in the first place, to compound yarns resulting from twisting worsted or woollen with cotton, an important class of manufacture is found in covert coatings and thin costume fabrics. The pure wool product is woven in the Venetian and the seven-end fine twill,* the warp yarn being worsted or woollen twist, with single worsted or woollen

*For "Weave Types" see *Standard Cloths: Structure and Manufacture.*

for weft. The shades in which such goods are commonly obtained are drab, brown, olive and green. In each colouring a dark shade is twisted with a light shade in making the twist warp thread, the colour of the weft selected matching the dark tone. Such types of fabrication, and the varieties of twist-yarn textures of which they are illustrative, are, in all technical features, suitable for production in union-twist warp and bi-fibred weft yarns. Under this classification, the specimens reproduced in Figs. 82 to 86 will be examined. They comprise the covert coating scheme of construction, and likewise the systems of looming included in the origination of ribbed and twilled cloths having twist yarns in the warp. Figs. 82, 82A and 83 are ribbed stripes with fine-twilled sections, A; Fig. 84 represents the ordinary style of twist-warp twilled texture, and Figs. 85 and 86 the twilled cloth in twist and bi-fibred warp threads. The following are typical of the methods of manufacture practicable—

SPECIMEN, FIG. 82

Warp.

	40	threads of	(*a*) 40's worsted and 40's cotton twist.
	2	,,	(*b*) 26's cotton and 60's worsted twist.
	4	,,	(*c*) 2-fold 48's bi-fibred worsted $^{80W}/_{20C}$.
	2	,,	(*b*)
	40	,,	(*a*)
Repeat	4	,,	(*c*)
	2	,,	(*b*)
	8	,,	(*a*)
	4	,,	(*c*)
	2	,,	(*b*)

20's reed 4's.

Weft.

22's bi-fibred worsted $^{80W}/_{20C}$.* 80 picks per inch.

SPECIMEN, Fig. 83; Plan Fig. 83A

Warp.

Repeat	12	threads of	(*a*) 2-fold 60's bi-fibred worsted $^{60W}/_{40C}$.
	14	,,	(*b*) 60's worsted and 48's cotton twist.
	12	,,	(*a*)
	64	,,	(*b*)

*W=Percentage of wool fibre.
C= ,, ,, cotton ,,

Weft.

28's bi-fibred worsted $^{80W}/_{20C}$.

108 threads and 96 picks per inch.

SPECIMEN, Fig. 84; Plan, 2-and-2 twill

Warp.

14 threads of 30 skeins woollen and 12's cotton twist.
2 ,, 16 skeins bi-fibred woollen $^{75W}/_{25C}$.

9's reed 4's.

Weft.

30 skeins woollen and 12's cotton twist.

34 picks per inch.

SPECIMEN, Fig. 85; Plan, Fig. 85A

Warp.

30 Threads { 1 thread of (*a*) 40 skeins woollen and 15's cottontwist, face yarn.
1 ,, (*b*) 22 skeins bi-fibred woollen $^{50W}/_{50C}$=backing yarn.

4 Threads { 1 ,, (*c*) 22 skeins bi-fibred woollen $^{75W}/_{25C}$=dark shade, face yarn.
1 ,, (*b*)

30 Threads { 1 ,, (*a*)
1 ,, (*b*)

8 Threads { 1 ,, (*c*)
1 ,, (*b*)

13½'s reed 4's.

Weft.

2 picks of (*c*) = face yarn.
1 ,, (*d*) 15 skeins bi-fibred woollen $^{50W}/_{50C}$=backing yarn.

68 picks per inch.

SPECIMEN, Fig. 86; Plan, 2-and-2 twill face, plain weave back, arranged 1 face, 1 back and 1 face in warp and weft.

Warp.

14 threads of (*a*) 16 skeins bi-fibred woollen $^{85W}/_{15C}$=dark shade.
13 ,, (*b*) 30 skeins woollen and 10's cotton twist
8 ,, (*a*)
7 ,, (*b*)
6 ,, (*a*)
6 ,, (*b*)

9½'s reed 6's.

Weft.

16 skeins of bi-fibred woollen $^{65W}/_{15C}$.

52 picks per inch.

107. *Typical Specimens Analysed.*—The effects seen in the specimens would ensue in wool-dyeing the pieces a dark shade. Parts A of Fig. 82, 82A, and 83 exemplify the covert coating style of manufacture, and part C, Fig. 82, illustrates the plain rib make of cloth ; or these sections illustrate the two textural structures in Figs. 87 and 88, the Venetian and ribbed types of fabric. Twist yarns form the warp of the two latter examples, which, in the union principle of construction, may consist of such counts as 60's worsted and 40's cotton for fine textures, and 40's worsted and 30's cotton, or 32's worsted and 20's cotton, for textures of a coarser grade. Fig. 87 is weavable in the first of these twists and Fig. 88 (Plan, Fig. 75A) in the medium counts. The weft should be a single-spun carded or combed yarn, or a bi-fibred woollen or worsted, according to the quality of cloth desired. Warp twill, plain rib, and cord weaves are combined in the patterns in Figs. 82 and 83. Example 82 contains three kinds of yarn, a 40's worsted and 40's cotton twist for the twilled features, a 26's cotton and 60's worsted twist for the threads marked in ⊡'s, and 2-fold 60's bi-fibred worsted for the cord B and the details in ⊡'s ; or threads (*a*), (*b*) and (*c*) in the warping plan. Yarns (*b*) have a fuller cotton ingredient than yarns (*a*), and develop, as a consequence, the thin lines edging the ribbed effects. The combination of these twists in this relation, suggests the method of obtaining technical distinctiveness in tinting, in the same counts of two-ply yarn, by interchanging the counts of the single threads, the worsted being the thicker and the cotton the smaller in twist (*a*), and the two thread units—worsted and cotton—being of a like diameter in twist (*b*). Threads (*c*), when crossed with the 22's bi-fibred worsted weft, render the strippings B and C in dark tones. A further feature is evident in Fig. 83—Plan 83A—due to the twilled lines C, woven in the bi-fibred warp yarns (*a*) consisting of 60 parts of wool and 40 parts of cotton, and taking, in the dyeing process, an intermediate shade of colour. Stripes A are formed in 60's worsted

and 48's cotton twist, and the cords in the 28's bi-fibred weft yarn. The latter, being spun of 80 per cent. of wool and 20 per cent. of cotton fibre, develops the 4-and-4 weft rib lines, B, in a dark shade, covering the 2-fold 60's worsted warp.

108. *Single and Backed Structures.*—Specimens 84 and 85 are two varieties of twist-warp pattern, the first being made in the common twill, and the second in the 3-and-3 twill, arranged 1 face and 1 backing in the warp, and 2 face and 1 backing in the weft. The diameters of the 30 skeins woollen and the 12's cotton in the twist yarn in the Fig. 84, are in the ratio of $\frac{1}{7\cdot5} : \frac{1}{8\cdot6}$; or the percentage of wool to cotton in the twofold thread is as 56·7 : 43·3. These discrepancies, in the

FIG. 85

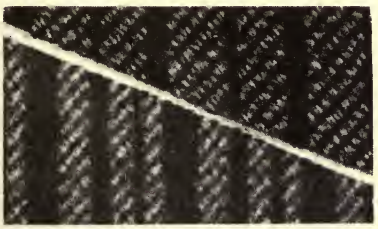


FIG. 86

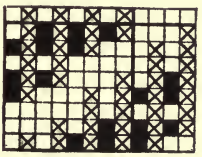


FIG. 85A

single ends, slightly accentuate the black or dyed elements in the cloth, as contrasted with the white or undyed elements resulting from the cotton threads in the twisted yarns. The faint lines—almost rendered invisible in the cloth by being crossed with the twist weft—are traceable to the union woollen yarns in the warping. The functions of the several threads are more varied in Fig. 85, the back of the fabric being in this instance woven in single 22 skeins warp (*c*) and 15 skeins weft (*d*). In addition threads (*c*) stripe the face in conjunction with the twist threads (*a*). Wool and cotton dyeing is preferable to single process piece dyeing in this and similar descriptions of compound-yarn fabrics. The backing yarn, containing equal quantities of cotton and wool fibre, yields a dull, grey shade if only wool tinting should be practised. This, if the piece should be coloured black, may not

be considered unsatisfactory; but should it be coloured brown, blue, etc., the whole toning may be improved by treating both the vegetable and the animal fibre with colouring matter—the wool fibre and woollen yarn being dyed a dark shade, and the cotton fibre and the cotton yarn a light tint.

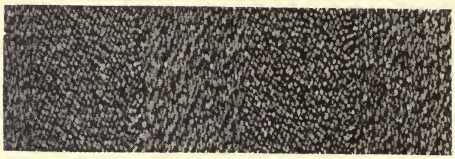


Fig. 87

109. *Contrasts Betwixt Single and Twist Yarn Textural Features.*—Stronger contrasts between the single and twist yarn features are seen in Fig. 86 than in Fig. 85, which are caused by the cotton unit in the twist being softer spun in the latter than in the former, and by the finishing practice differing in the two textures. Increasing the diameter of the cotton—with a smaller number of turns per inch—relative to the diameter of the woollen, adds to the emphasis of the untinted fibrous quantities in the fabric. Such technicalities tend, however, to produce harshness of textural tone, providing the cloth is not finished with a raised surface. Fig. 86 indicates that the twist stripings, as two-fold thread effects, may be partially obliterated in this manner. Treating the piece in a damp condition by the teazle or card-wire points in the raising process, intermingles the filaments of the woollen and cotton threads in the twist yarn, and imparts a fibrous, wool character to the twilled details in the cloth. Whereas, in Fig. 85, the object, in finishing, has been to leave the twist threads clear and distinct and the weave intersections well defined, raising the pieces dry and removing the face fibre

Fig 88.

in cutting, in Fig. 86, the object has been to conceal the twist structure and to subdue the textural elements characteristic of the twilled make of the fabric. For the production of the former qualities the single ends, in the twist, are medium spun with a possible increase in the turns per inch in the doubling, but for the latter qualities, the cotton is specially loosely spun, with a possible reduction in the turns per inch in each thread in the twisting operation.

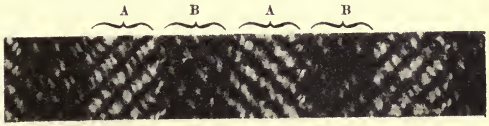


Fig. 89

110. *Interchanging the Counts of the Thread Units.*—The style of effect producible in the texture by interchanging the counts of the thread units in the twist yarn has been pointed out in reference to the light edging lines of the cord stripes in specimen 82. Seeing that each thread in the folded yarn is either a colourable or an undyed feature in the fabric, it has a specific value on the tone of the pattern. A simple striped example—Fig. 89—will show the textural characteristics obtainable by thus altering the counts of the respective threads in a given size of twist thread. This striping is warped 12 threads of (*a*), 15 skeins woollen and 9's cotton twist, and 12 threads of (*b*) $4\frac{1}{2}$'s cotton and 30 skeins woollen twist, and wefted with 10 skeins woollen yarn. The "setting" diameter of each twist thread is $\frac{1}{42}$; that of the woollen thread in (*a*) $\frac{1}{58}$ and of the cotton $\frac{1}{76}$; and that of the woollen in (*b*) $\frac{1}{75}$

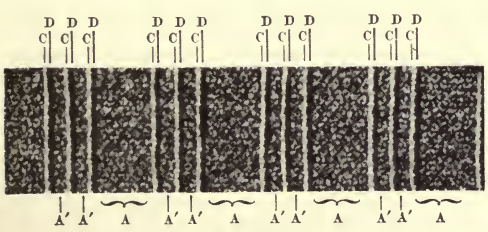


Fig. 90

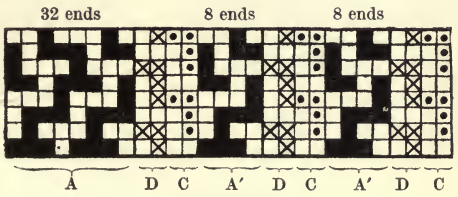


Fig. 90A

and of the cotton $\frac{1}{5\,4}$. It follows that in wool-dyeing the piece a dark shade, threads (*a*) form the bands in a deep tone and threads (*b*) in a light tint, as seen in the fabric. The tone depth of stripe A is increased as compared with that of B by the quality of the woollen weft. If this were modified to contain from 30 to 40 per cent. of cotton fibre, it would equalize the tinted effects originated by the twist yarns.

111. *Limitations in "Count" Differentiations.*—Too great a differentiation, in the counts of the single threads, results in an unbalanced textural structure, particularly if the two sorts of twist thread are combined in considerable group sections. The inequalities may, in such arrangements, be to some degree neutralized by the systematic insertion, into the warping and wefting, of ends and picks of bi-fibred yarn. Taking the scheme in Fig. 89, larger stripings might be acquired, and also an even quality of cloth manufactured, by combining the twist with single-spun threads on the lines indicated below—

SPECIMEN, Fig. 89; modified

Warping.	24 threads.			24 threads.		
Twist (*a*) 15 skeins woollen and 9's cotton	1	2	1	–	–	–
,, (*b*) 4½'s cotton and 30 skeins woollen	–	–	–	1	2	1
10 skeins bi-fibred woollen (*a'*) $^{65W}/_{35C}$	1	1	–	–	–	–
,, ,, ,, (*b'*) $^{35W}/_{65C}$	–	–	–	1	1	–

Weft I.
10 skeins bi-fibred woollen (*a'*).

Weft II.
10 skeins bi-fibred woollen (*b'*).

Weft III.
1 pick of 10 skeins woollen.
1 ,, (*a'*) or (*b'*).
1 ,, 10 skeins woollen.

Weft IV.
2 picks of 10 skeins woollen.
1 pick of (*a'*).
2 picks of 10 skeins woollen.
1 pick of (*b'*).

Weft V.
Same order as warping plan.

112. *Equalization of Fabric Quality in Broad-striped Patterns.*—According to this warping plan the twists of an excess percentage of wool filament are intergrouped with the bi-fibred yarns of an excess percentage of cotton fibre, and

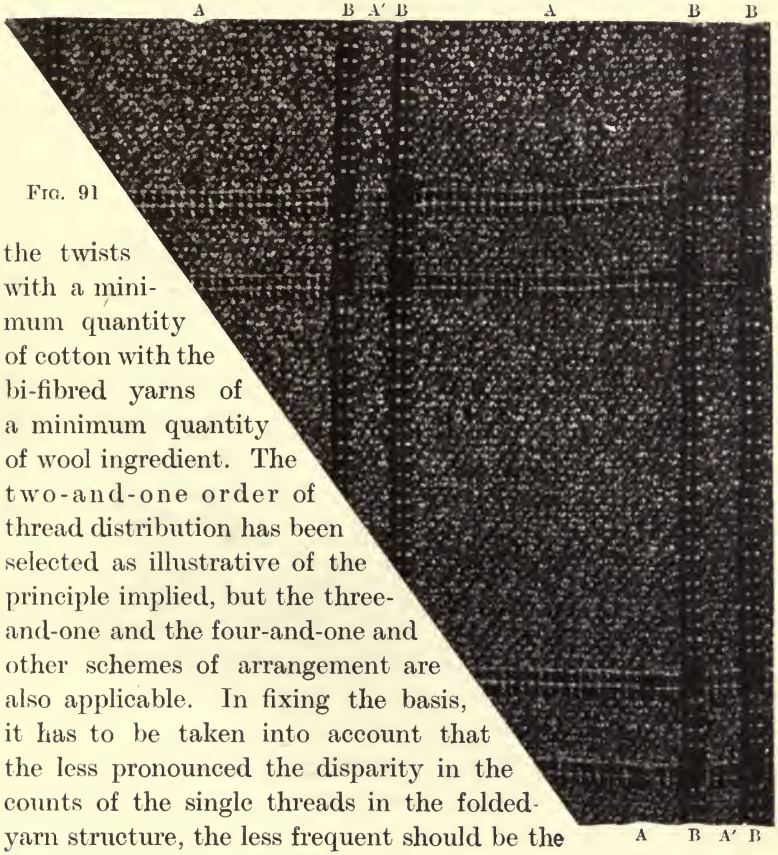


FIG. 91

the twists with a minimum quantity of cotton with the bi-fibred yarns of a minimum quantity of wool ingredient. The two-and-one order of thread distribution has been selected as illustrative of the principle implied, but the three-and-one and the four-and-one and other schemes of arrangement are also applicable. In fixing the basis, it has to be taken into account that the less pronounced the disparity in the counts of the single threads in the folded-yarn structure, the less frequent should be the insertion of the bi-fibred threads in the warping plan, and, conversely, the greater the difference in the thickness of the thread units in the twist, the more frequent should the bi-fibred yarns be introduced into the scheme for the purpose of equalizing the textural quality, subjective to disturbance by the alternate grouping of twists the reverse of each other in filament consistency, as in the yarns (*a*) and (*b*) of the example.

Five systems of wefting are shown. No. 1 and 2 equally preserve the fibrous composition of the fabric as controlled by the warping scheme, but the first weft (*a'*) also supplements the wool ingredient in the cloth, and, in the dyeing of the piece, it would take a deep shade; whereas the second weft (*b'*) would give a more economic union production, and develop a mixture tone consisting of 65 per cent. of colour and of 35 per cent. of untinted fibre. Weft III attains an intermediate

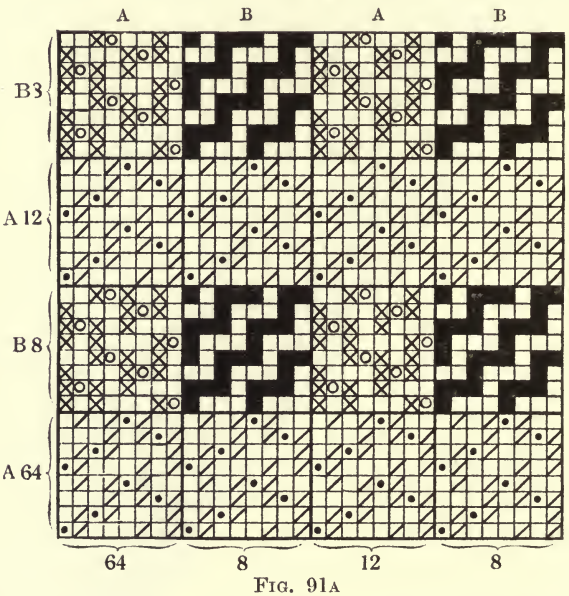


FIG. 91A

grade of texture between Wefts I and II, and results in two picks of the weave being woven in woollen yarn to one pick being woven in yarn (*a'*) or (*b'*); while Weft IV retains the complement of woollen picks alternating with odd picks of each of the bi-fibred threads. Each of these wefts is effective in defining the striped features in the pattern as illustrated in Fig. 89, and each gives a distinctive style of textural tinting, so that they would be severally applied in pattern range origination, dyeing each type of manufacture, as determined by the yarn assortment, five, six, or more mixture

colours. The last weft in the series—No. V—corresponding to the warping arrangement, changes the form of the design, making a checked combination, but one in which the twist-yarn features would be less marked than in Fig. 89, owing to the toning qualities of the threads (*a'*) and (*b'*).

Fig. 92

The scheme of practice described may be suitably elaborated in the construction of striped compounds, resulting from the admixture, in group order, of twist yarns the reverse of each other in thread units, and therefore in filament ratio. As indicated, it neutralizes the textural inequalities which the assortment of such yarns imposes, and, at the same time,

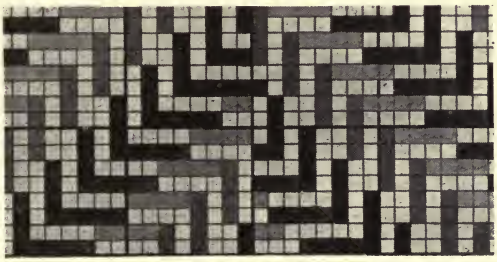


Fig. 92A

develops a special class of fabric tinting and fibrous quality of union manufacture.

113. *Twists, Single-quality, and Bi-fibred Yarns Combined.*—The combination of union twists with single yarns spun from one kind of fibre, and with yarns of the bi-fibred formation, is practicable in the weaving of striped and checked patterns of the character illustrated in Figs. 90 and 91. The cloths

are of the backed principle of intertexture, and may be obtained in the following looming data—

SPECIMEN, Fig. 90; Plan, Fig. 90A

Warp.

	32 threads	1 thread of	(*a*) 36 skeins woollen and 12's cotton twist.
		1 ,,	(*b*) 18 skeins bi-fibred woollen $^{50W}/_{50C}$.
Repeat		1 ,,	(*c*) 16's cotton.
		1 ,,	(*d*) 18 skeins woollen.
		1 ,,	(*d*) 18 skeins woollen.
		1 ,,	(*c*) 16's cotton.
	8 threads	1 ,,	(*a*)
		1 ,,	(*b*)
		1 ,,	(*c*)
		1 ,,	(*d*)
		1 ,,	(*d*)
		1 ,,	(*c*)

43's reed 4's.

Weft.

1 pick of	(*a*)
1 ,,	(*b*)
1 ,,	(*a*)
1 ,,	(*d*)

48 picks per inch.

SPECIMEN, Fig. 91; Plan, Fig. 91A

Warp.

A64	Threads	1 thread of	(*a*) 24 skeins woollen and 9's cotton twist.
		1 ,,	(*b*) 13 skeins bi-fibred woollen.
B8	Threads	1 ,,	(*b*)
		1 ,,	(*a*)
A'12	Threads	1 ,,	(*a*)
		1 ,,	(*b*)
B8	Threads	1 ,,	(*b*)
		1 ,,	(*a*)

Weft.

1 pick of	(*a*)
1 ,,	(*b*)

48 ends and 40 picks per inch.

114. *Specimens in Multi-quality Yarns.*—It is clearly understood that wool-dyeing the pieces would colour the woollen

yarns and wool ingredients in the bi-fibred threads, and leave the cotton yarns—single spun (*c*) or twisted (*a*)—white or untinted, but the method of looming relative to the fabric structure and the design plans—Figs 90A and 91A—needs some explanation.

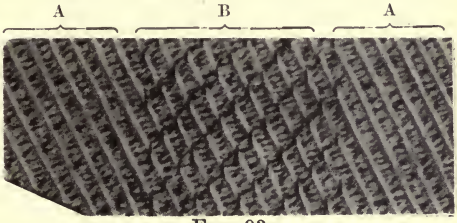


FIG. 93

The solid black and white lines and also the mingled effects in bands D, C and A in Fig. 90 are woven respectively in threads (*d*), (*c*) and (*a*). Plan Fig. 90A causes the twist yarns in the warp and in the weft to interweave on the face of the cloth in sections A and A′ and on the back of the piece in sections C and D. The second and fourth picks in the wefting cover the white (cotton) and black (woollen) face ends in the plan, and these only. Hence they have no effect in other parts of the pattern, in which they interlace with the threads in the warping forming the underside of the fabric. The order of the warping, and the construction of the design, provide for woollen *under* cotton threads and cotton *under* woollen threads, which approximately balances the filament ratio, in the fine lines, with the twist-yarn sections of the fabric. Any description of striping, in these effects, is obtainable with the thickness of the yarns, and with their structural composition varied, to agree with the quality of union manufacture requisitioned.

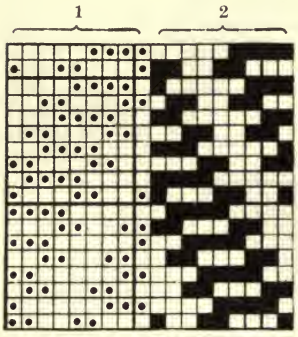


FIG. 93A

Section 2 forms the plan for Fig. 93. The style is also weavable in angled twill as illustrated.

115. *A Checked Example.*—Checked forms of pattern necessitate a different scheme of weave plan. Fig. 91 has been produced in the design sketched in Fig. 91A, a warp-backed broken swansdown compound, in which sections A and B

are the reverse of each other. The former give the twist yarns (*a*), in the warp scheme, on the face and the bi-fibred yarns on the back of the texture, and the latter, B, interchange the positions of the two groups of threads. This explains the construction in the pattern of the rectangular features in twist and in the dark-toned yarn. Changing the order of grouping the threads in the warping, has a like result to changing the position of the face and backing threads in the plan, which accounts for the lines B, B, coinciding with the alterations in the warping arrangement. The broken effects on lines B′, B′ in the specimen are due to the transposition of the two kinds of warp yarn in the weave design. In parts A of the pattern the twist threads interlace with the twist picks; in the small checked details, the bi-fibred warp with the bi-fibred weft yarns, and in Parts B, B and B′, B′, the twisted and bi-fibred threads intercross with each other. Warping Sections A in twist and Sections B in single yarn, is another system of developing this type of checking, but the design scheme, in either practice, requires to be devised to fit with the character of the pattern intended.

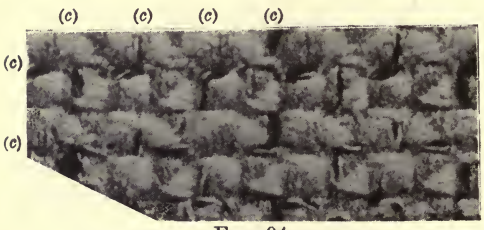


FIG. 94

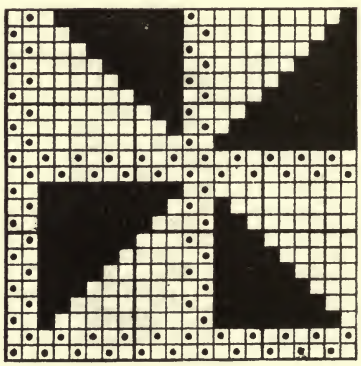


FIG. 94A

The two examples—Figs. 90 and 91—may be taken as demonstrating the connection of the weave plan with style and textural variations, resulting from combining twists and bi-fibred threads in the warp and weft of the cloth. Fig. 90A particularly illustrates the principle of arranging and

classifying the intersections in the design to emphasize certain pattern elements in a striped relation, and Fig. 91A the principle of grouping and interchanging the weave units for checking purposes, in a given scheme of warping and wefting. Both plans also suggest design construction for giving different yarns, in a prescribed order, on the face or back of the texture, and for acquiring by the scheme of yarn interlacing a specific grade of woven manufacture.

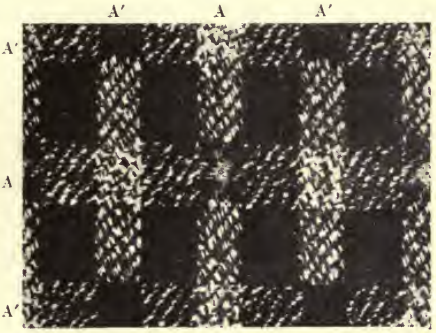


FIG. 95

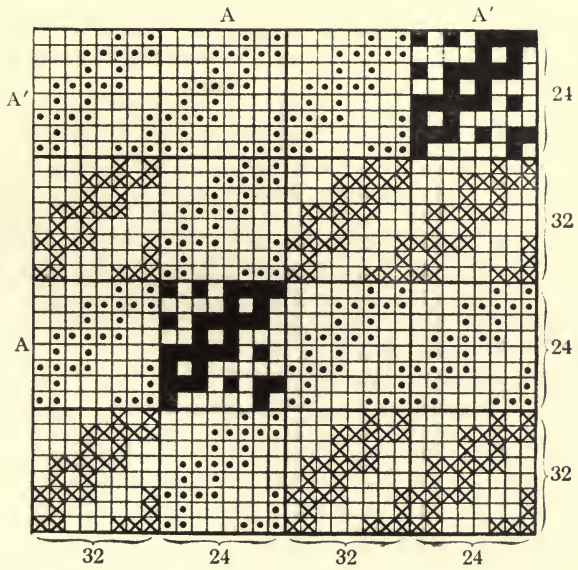


FIG. 95A

116. *Light-Coloured Ground Patterns.*—Patterns with a light-coloured ground are procurable by tinting either the cotton or the woollen thread units in the twist yarn. Whichever

material is selected for dyeing, it gives the distinguishing filament quality to the fabric. Three specimens—Figs. 92, 93 and 94—will be examined. The first is typical of the yarn assortment for obtaining light and dark tinted features; the second for acquiring a faint-tinted groundwork with details developed in darker tones; and third for producing cloths in which the warp yarn is tinted while the weft yarn, in the dyeing process, remains in the natural colour of the material employed in spinning. The methods of manufacture, particularized below, will enable this scheme of union fabric construction and design to be succinctly described.

SPECIMEN, Fig. 92; Plan, Fig. 92A (Angled)

Warp and *Weft.*

	4 Threads	1 thread of	(*a*)	2-fold 32 skeins woollen.
		1 „	(*b*)	30 skeins woollen and 10's cotton twist.
	4 „	1 „	(*b*)	
		1 „	(*a*)	
	6 „	1 „	(*a*)	
		1 „	(*b*)	
	6 „	1 „	(*b*)	
		1 „	(*a*)	
	10 „	1 „	(*a*)	
		1 „	(*b*)	
	8 „	1 „	(*b*)	
		1 „	(*a*)	
Repeat	6 „	1 „	(*b*)	
		1 „	(*a*)	
	6 „	1 „	(*b*)	
		1 „	(*a*)	
	8 „	1 „	(*a*)	
		1 „	(*b*)	
	10 „	1 „	(*b*)	
		1 „	(*a*)	
	6 „	1 „	(*a*)	
		1 „	(*b*)	
	6 „	1 „	(*b*)	
		1 „	(*a*)	
	4 „	1 „	(*a*)	
		1 „	(*b*)	

SPECIMEN, Fig. 93; Plan, Fig. 93A

Warp.

74 threads of (*a*) 2-fold 28's bi-fibred worsted, $^{85W}/_{15C}$.

70 Threads { 2 ,, (*b*) 24's worsted and 24's cotton twist.
1 thread of (*a*)
2 threads of (*b*)

Weft.

1 pick of (*a*)
1 ,, (*b*)

SPECIMEN, Fig. 94; Plan, Fig. 94A

Warp.

(*a*) 2-fold 9's worsted, with odd threads at intervals of (*c*) 12's worsted and 4's cotton twist.

Weft.

(*b*) 6's worsted and 12's cotton twist, with overchecking picks, (*c*), consisting of 12's worsted and 4's cotton twist.

117. *Variations in the Diameters of the Single Thread Units.*—The three specimens suggest the relative thicknesses of the single threads, in the counts of the twist yarns quoted, for obtaining the textural contrasts illustrated. Each type of fabric is adapted for cotton dyeing, but in Fig. 93 the wool fibre, in the 2-fold 28's worsted, has also been colour-stained.

When the effects, in the pattern woven, due to the twist threads and picks, are intended to be as clearly delineated as in Fig. 92, the cotton yarns should be approximately of the same counts, or a degree finer, than the counts of the woollen yarns with which they are twisted, or, as shown in this specimen in which twist (*b*) is composed of 30 skeins woollen and 10's cotton. It will be apparent that this description of union fabric might be produced by using coloured and white twist yarns in the weaving of the piece ; but the method described is the more economical in practice, admitting of the cloth being woven in the grey, and of the goods being dyed to any suitable assortment of shades, and by two systems of treatment—first, by tinting the cotton as in the example, and, second, by dyeing the cotton a dark and the woollen threads

FIG. 96B

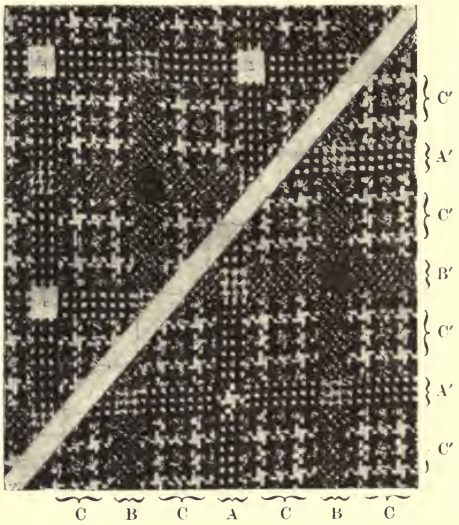


FIG. 96

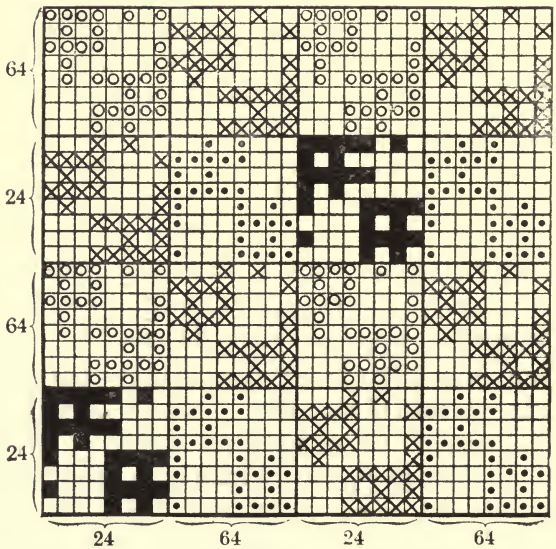


FIG. 96A

a pale colour. It should, however, be noted that, unless in the latter instance, the shades selected for the woollen and cotton thread units are sufficiently removed from each other in the chromatic scale, the design details, resulting from the twist yarns, are likely to suffer in definition if not to appear somewhat blurred in tone.

118. *Bi-fibred Yarns and Twist Threads.* — Fig. 93, as indicated, is coloured in the worsted as well as in the cotton twist threads (*b*), but the employment of a bi-fibred yarn similar to (*a*) would render the tinted features producible by cotton dyeing. The single process of tinting is necessarily restricted to the production of one line of colour in both threads (*a*) and (*b*), and it follows that, if the pale tint of the worsted in the fabric is required to be different in colour hue from the cotton, the two-process system of dyeing is involved, for which the yarns (*a*) would be spun from wool fibres solely. The warp furrows in the weave, Fig. 93A, continue the twilled lines, seen in the specimen, over the twist weft in both stripings A and B; but, in the latter, threads (*b*) in the warping, develop the diagonal features moving to the right. The 24's cotton, in the two-ply yarns, is dyed a dark shade in the piece, which process would merely tint the 2-fold 28's bi-fibred worsted should it consist of 85 parts of wool and 15 parts of cotton. Increasing the percentage of the vegetable fibre would darken

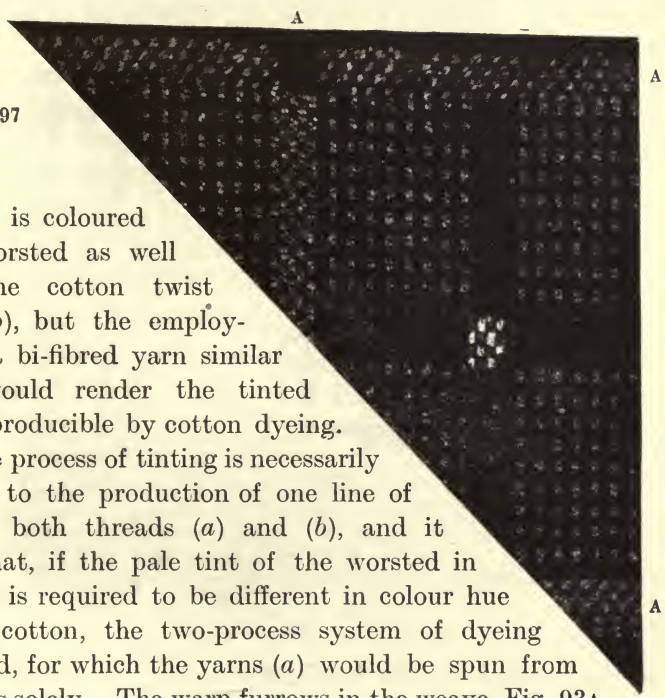


FIG. 97

the tone of the ground of the texture, and subdue the detail effects woven in the worsted and cotton twists.

119. *Union-Worsted Twist and Union-Worsted Yarns.*—Specimen 94 is formed in a worsted warp crossed with a worsted and cotton twist yarn equal in size to a 2-fold 9's worsted. The cotton, however, being doubled with a 6's worsted yarn is so much smaller than the latter, that, in colouring this thread in the fabric, a softened tinted contrast

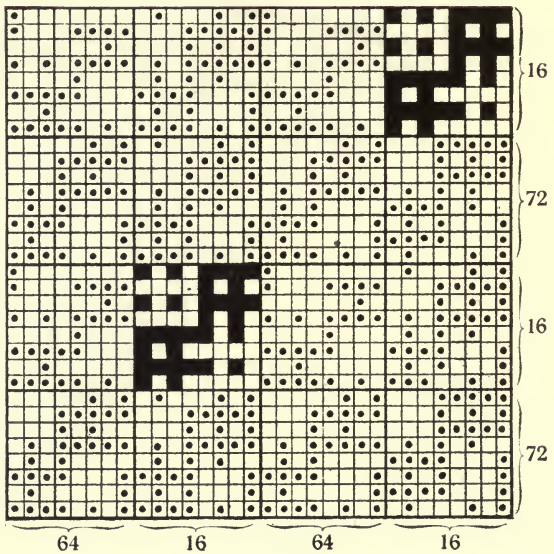


FIG. 97A

is the result between the shade tones of the warp and weft yarns. The interchange in the counts of the threads in the twists for the odd overchecking ends and picks, causes threads (*c*) to yield a distinct tinted element in the pattern. For the weft in this class of production, a bi-fibred yarn may also be used, which would emphasize the effects due to the special twist yarns, but detract from the character of the weave design as acquired by the interlacing, as explained, of the 2-fold worsted warp threads with the worsted and cotton twist picks.

120. *Patterns with Dark-toned Grounds.*—Fabrics with dark-coloured grounds comprise the same variety of technicalities of construction as those referred to under Figs. 92, 93 and 94. The twist yarn structure, and filament analysis of the bi-fibred threads, determine the quality of the shade tones produced in the fabric, but by dyeing the wool instead of the cotton fibre in the piece goods. Three examples, of which the details of manufacture are specified, will be examined.

SPECIMEN, Fig. 95; Plan, Fig. 95A

Face Warp.

16 threads of (*a*) 30 skeins woollen.
12 ,, (*b*) 40 skeins bi-fibed woollen $^{60W}/_{40C}$ and 20's cotton twist.

Backing Warp.

24 threads of (*a*)
4 ,, (*c*) 30 skeins bi-fibred woollen $^{75W}/_{25C}$.
24 ,, (*a*)
4 ,, (*d*) 30 skeins bi-fibred woollen $^{50W}/_{50C}$.

16's reed 4's.

Weft.

32 picks of (*a*)
8 Picks { 1 pick of (*e*) 32 skeins woollen and 25's cotton twist.
1 ,, (*a*)
8 Picks { 1 ,, (*b*)
1 ,, (*a*)
8 Picks { 1 ,, (*e*)
1 ,, (*a*)

56 picks per inch.

SPECIMEN, Fig. 96; Plan, Fig. 96A

Face Warp.

12 Threads { 2 threads of (*a*) 9's cotton.
2 ,, (*b*) 28 skeins woollen.
C { 2 ,, (*c*) 30's worsted and 24's mercerized cotton twist.
4 ,, (*b*)
4 ,, (*a*)
4 ,, (*b*)
4 ,, (*c*)
4 ,, (*b*)
4 ,, (*a*)
4 ,, (*b*)
2 ,, (*c*)
*12 ,, (*c*)

Repeat C.

Backing Warp.

4 threads of (*d*) 2-fold 24's cotton.
4 ,, (*e*) 28 skeins bi-fibred woollen $^{50W}/_{40C}$.
4 ,, (*d*)
32 ,, (*b*)
*12 ,, (*b*)
32 ,, (*b*)

Weft same as *Warp*.

72 threads and 68 picks per inch in the loom.

SPECIMEN, Fig. 97; Plan, Fig. 97A

Face Warp.

32 Threads { 2 threads of (*a*) 32 skeins woollen.
2 ,, (*b*) 36's worsted and 24's cotton twist.
8 ,, (*a*)
32 Threads { 2 ,, (*a*)
2 ,, (*b*)
8 ,, (*b*)

Backing Warp.

32 threads of (*a*)
8 ,, (*c*) 32 skeins bi-fibred woollen $^{50W}/_{50C}$
40 ,, (*a*)

Face Weft.

80 picks of (*a*)
8 ,, (*b*)

Backing Weft.

36 picks of (*a*)
8 ,, (*b*)
44 ,, (*a*)

72 ends and 60 picks per inch in the loom.

121. *Utility of Double-make Cloths in Yarn Distribution.*—The double-make principle of cloth is utilized, in the construction of these examples, for the purpose of reversing the positions of the face and backing yarns, as required in the development of the effects in the pattern. Taking Fig. 95, the design, Fig. 95A, is a compound of double cassimere twill. In the ground sections, marked in ⊠'s and ⊡'s, the odd

* The design is arranged to transpose these threads in the fabric, forming the dark rectangular spot seen in the specimen, Fig. 96.

threads and picks form the face, and the even threads and picks the backing texture, but in the sections marked in ■'s, the two series of threads and picks are transposed. Fig. 96A is more complex in arrangement, consisting of four systems of grouping the face and backing yarns and of two types of double weave. Dissecting the plan gives the following analysis—

(1) Sections marked in ⊠'s, mat face and twill back, arranged 1 face and 1 back in both warp and weft.

(2) ,, ,, ⊡'s mat face and twill back, arranged 1 back and 1 face in the warp, and 1 face and 1 back in the weft.

(3) ,, ,, ⊡'s mat face and twill back, arranged 1 face and 1 back in the warp, and 1 back and 1 face in the weft.

(4) ,, ,, ■'s mat face and mat back, arranged 1 back and 1 face in both in warp and the weft.

Fig. 97A comprises double weaves consisting of mat combined with $\frac{2}{2}$, $\frac{3}{1}$, and $\frac{1}{3}$ twills. The three examples considered are instructive as showing the relation of weave elements to the schemes of warping and wefting in this class of union production. This relation is identical, as a design principle, with that applied in the textural development of compound colour patterns. The different yarn structures and qualities in the orders of warping and wefting, are treated as the equivalents of the shade tones obtainable in the dyed fabric. The weave plans are constructed on a basis which absolutely agrees with the classification of the yarns in the warp and in the shuttling. Thus, in Fig. 95 the face warp consists of 30 skeins woollen and of 40 skeins bi-fibred woollen and 20's cotton twist, the former, interweaving with weft (*a*), coincides with the dark features in the pattern, and the latter, interweaving with the wefts (*b*) and (*e*), coincides with the twist-yarn checkings, or with the sections in the design, Fig. 95A, printed in ■'s and ⊡'s, and in ⊠'s respectively. The black spaces on lines A′

of the specimen, Fig. 95, are caused by the interchange in position of the face and backing yarns, the sections of the plan in ■'s effecting this. For a like reason the grey details on lines A are developed in threads (*c*) and (*d*) of the backing warp, which are shown on lines A of the design as brought on to the face of the fabric. An added whiteness of tone may be imparted to the twist threads (*b*) by forming them of bi-fibred woollen, instead of woollen and cotton yarns. A similar tone might be also acquired by doubling a 10's, instead of a 20's, cotton with a small worsted thread, but the twist effects in the fabric would in this instance not present the mingled tinted quality they possess in the specimen as produced.

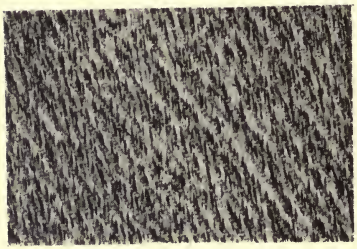


FIG. 98

122. *Compound Checking in Yarns of Different Structures.*— The face warp of Fig. 96 is composed of 9's cotton, 28 skeins woollen, and of 30's worsted and 24's mercerized cotton twist. The white elements are woven in the threads and picks (*a*), the black ground in (*b*) and the twist details in threads and picks (*c*). The features on lines A, A′ and B, B′ are produced in the weaves in the design—Fig. 96A—marked in ■'s, ⊡'s and in ⊠'s; and on the lines C, C′ in the weaves marked in ⊠'s and in ⊡'s. The backing warp and weft contains additional varieties of yarn, including 2-fold 24's cotton and 28 skeins bi-fibred woollen ends, or yarns (*d*) and (*e*), giving the white star check in grey on lines A and A′. Fig. 96B is a modified yarn grouping of Fig. 96, the first twelve threads in the backing warp—which are transferred to the face of the cloth by the section in the plan printed in ■'s—being

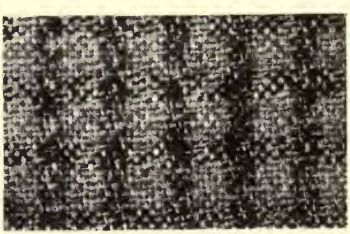


FIG. 99

composed of 2-fold 24's cotton. Three sorts of yarn are combined in Fig. 97, namely, threads (*a*) making the dark ground, threads (*b*) the mat details, and threads (*c*) developing a grey tone, which, in the texture, modifies the tinted character of the spaces on the twist lines A, represented in black in the weave compound, Fig. 97A.

123. *Linen and Cotton Twist Unions.*—Linen and cotton twist unions are ordinarily woven in the colour tones in which the fabrics are dressed or finished. The two specimens in Figs. 98 and 99 are illustrative of the general character of the style of textural effects obtainable in plain and twilled textures by retaining the linen thread in the unbleached or natural colour, and by tinting the cotton thread unit in the twisted yarns. The warp in Fig. 98 is made of 50's cotton and 170's linen twist, the texture being wefted with 25's single cotton and woven in the four-end twill. In Fig. 99 the light sections are formed of 56's linen and 60's cotton twist, and the toned sections in twist yarns obtained by doubling a 30's dyed with a 30's undyed cotton thread. Each specimen contains three tinted features, those in the first example being due to the combination, in twisting, of undyed linen and dyed cotton threads, and to crossing these with white cotton weft; and, in the second example, to the combination, in twisting, of undyed cotton and linen threads, and to the admixture of these, in the weaving, with 2-ply 30's cotton yarns composed of coloured and uncoloured thread units.

CHAPTER VII

MULTI-FOLD TYPES

124.—Yarns Diversified and Yarns Symmetrical in Formation. 125.—Surface Modification of Folded Yarns. 126.—Production of Thread Types. 127.—Tensility and Firmness of Folded-Thread Structures. 128.—Twist Yarns and Textural Characteristics. 129.—Reversible Fabric in Compound Cotton and Linen Yarns. 130.—Clearness and Definition of Interlacing Details. 131.—Contrasts in Folded-Yarn Counts. 132.—Prominence and in relief character of Fabric Elements woven in Multi-fold Yarns. 133.—Yarn Doubling and Pattern Origination. 134.—Diamond and Chain Twists—Specimens. 135.—Specked and Spotted Yarns. 136.—Duplicating Spottings and Colourings. 137.—Specimen in Folded Cotton and Linen and Doubled Silk Threads. 138.—Mohair and Lustre Materials in Knopped Yarns. 139.—Rougher Grades of Fabrics and Multi-ply Union Threads. 140.—Mingled and Mottled Colour Toning. 141.—Folded Union Yarn Structures and Piece Dyeing. 142.—Curl Yarns. 143.—Finishing Practice and Fancy Folded Yarn Effects.

124.—*Yarns Diversified and Yarns Symmetrical in Formation.*—Yarn structure has now been treated of as a source of union cloth manufacture in its two fundamental aspects—(*a*) as the result of combining, in the processes of spinning, two or more varieties of fibre, and (*b*) as the result of combining, in the process of folding or twisting, several thread units spun from different sorts of material. In neither system is the object, as analysed, to produce a yarn of diversified formation and quality, but a yarn symmetrical in diameter, elasticity, filament composition and structural character. Multi-fold twist production also comprises the origination of yarns varied in lineal and in circumferential features, that is, yarns not only composed of thread strands dissimilar in fibrous consistency, thickness, and in methods of manufacture, but in which the respective threads have special and distinctive functions, imparting looped, specked, knopped, curled, flaked and other technical elements to the compound yarn product.

125. *Surface Modification of Folded Yarns.*—All bi-fibred and folded yarns may be modified as required in (1) counts or diameter, (2) in the separate thread units from which they are prepared, (3) in colour attributes, and (4) in tensility and firmness ; but twisted or compound yarns may also be modified in actual surface demarcations and properties. They are variable in size, differing in circumference measurement in portions of their length ; in certain prescribed dimensions they may be hard twisted and in others normally or loosely twisted ; or they may be made of threads of the same diameter, or of yarns varying from a fine counts of thread to a soft, thick slubbing or roving. Effects. amounting to pattern details, are, with the method of construction and the kinds of thread selected for folding purposes, thus obtainable in the "fancy" "multi-ply" as distinguished from the "plain" or ordinary twisted yarn.

Fig. 100

126. *Production of Thread Types.*—Each system of yarn modification defined is an elemental cause of textural differentiations, producing a thread type on which the make and style of the fabric manufactured are based. Single-spun and the simpler classes of twisted threads are alterable in filament compactness, elasticity strain, and in quality-giving value, by the degree of twine generated in the spinning of a definite counts of yarn, and also by the average fineness and length of the fibres in the materials of which they are formed. Should, for example, a change be made in the filament ingredients of a thread, as would be originated in making a 2-fold 30's worsted yarn of wool, and of equal parts of wool and cotton, respectively, the fabrics acquired from the two yarns would differ in filament consistency as derived from the aggregate diametrical proportions of the fibres as well as from their

structural distinctions. These points have a basic significance in the admixture of animal and vegetable fibres in spinning. The use of cotton with wool adds, as a rule, to the multiplicity of filament units in a given counts of yarn, and therefore to the filament density of the yarn, and of the cloth of a certain weight per yard. To diminish the numerical quantity of fibre in an all-wool yarn, though the size remains unchanged, necessarily involves the assortment of thicker and probably stronger

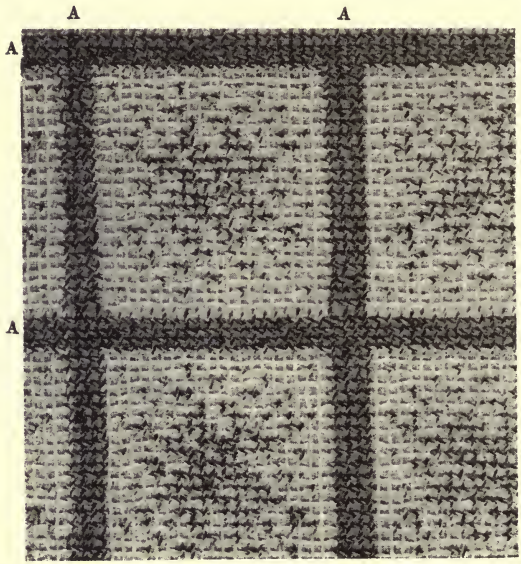


Fig. 101

fibres, with the production of a texture of reduced quality; but, on the other hand, to increase the ratio of fibre in the yarn with the size constant is attended with converse textural results. In the case, however, of a union yarn acquiring additional filament compactness from the vegetable material employed in its construction, the cloth resultant is finer but not of an improved "working" nature, as cotton does not, in this relation, contribute, in the same way as wool, to the values which provide "finishing" condition as discovered and utilized in the processes of felting, raising and lustring.

But it does imply that the yarn, being fuller of fibre, is adapted to the fabrication of cloths of a sound wearing strength. Further, it denotes that the turns per inch in the spinning of the thread may be raised as compared with a woollen or worsted thread of a similar counts, and this augmented twine, being in conformity with the filament distribution and composition of the yarn, induces the formation of a thread smooth and even on the surface, and of satisfactory tensile property.

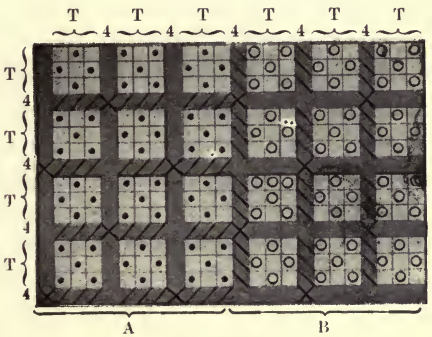


FIG. 101A

127. *Tensility and Firmness of Folded-Thread Structures.*—Regarding yarn tensility and firmness of structure, both factors are determined by

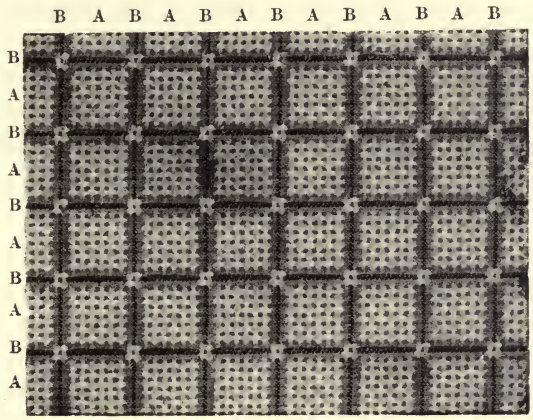


FIG. 102

(1) the average length of staple in the materials used and the degree of filament overlapping in the lineal direction of the thread; and (2) by the measure of twine inserted into the yarn in the operation of spinning. The usefulness and applicability

of folded threads are, in a secondary sense, modified by the former, inasmuch as the properties of the individual threads twisted together affect the character of the folded structure; and, in a primary sense, by the latter, as twine changes the hardness, compactness and manufacturing value of the ordinary classes of twist threads. Textural wear and durability, and textural softness and quality, suffer from a deficiency in elasticity in the spun and doubled yarns, whether consisting of threads of a corresponding or dissimilar thickness, and of the same or different classes of fibre. In a pre-eminent degree the smoothness or roughness, and the brightness or dullness of tone of the fabric, result from the nature of the raw material, but the system of yarn preparation, and especially of twist insertion, is a potent modifying factor. Without practising mechanical and other methods of constructing multi-fold in contrast with single-spun threads, the processes and routine of yarn-making may be regulated to fashion the grade and character of the woven manufacture. To punctuate this element of twine in relation to textural effect, in producing twist-warp goods unless the turns per inch are successively coincident with the picks per inch and the repeats of the weave, uniformity and evenness in the definition of the twist-yarn features in the fabric is rendered impracticable. That is, with the warp yarn made, for example, of 40's worsted (dark shade) and 40's cotton (light shade), the weave a four-shaft twill, and the weft a 22's bi-fibred worsted, the turns per inch in the folded yarn should be a multiple of the repetitions of the weave in a fractional length of the cloth. Thus in this piece setting, 34 twills in $2\frac{5}{16}$ in., and the yarn with 20 turns per inch, averaged a number of turns per twill that formed a satisfactory degree of correspondence between the two factors.

128. *Twist Yarns and Textural Characteristics.*—Twist yarns, simple or varied in fold and in method of construction, impart certain special characteristics to the woven result. The effects, for instance, of using black and white twist threads

are quite distinct in quality in the texture, from the effects obtained in yarns in which the two shades are admixed in

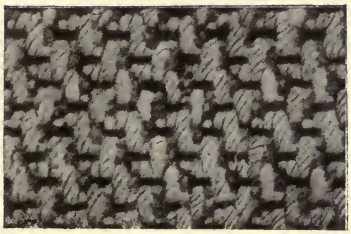


FIG. 103

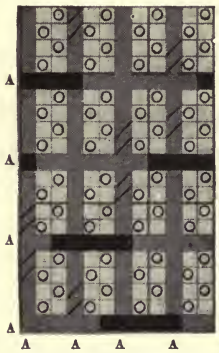


FIG. 103A

like proportions as in the twist but in the processes of thread preparation. A reference to the specimens in Figs. 100 and

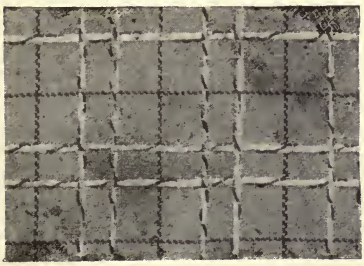


FIG. 104

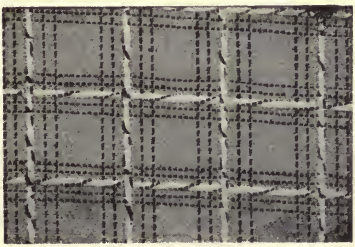


FIG. 104A

101 will make this clear. Fig. 100 is a plain texture warped and wefted as follows—

	12 threads,	6	6	12
(*a*) Black worsted	1 1	– –	1 1	– –
(*b*) Bi-fibred worsted $^{50W}/_{50C}$ . .	– –	1 1	– –	1 1
(*c*) 60's worsted (black) twisted with 40's cotton (white) . . .	1 –	1 –	1 –	1 –

Fig. 101 is a compound reversible fabric—sectional plan, Fig. 101A—in which the warp and weft are arranged, one

thread of 4-fold 85's linen and three threads of 40's black twisted with 40's mercerized white cotton.

129. *Reversible Fabric in Compound Cotton and Linen Yarns.*—The cotton twist threads, in the first example, accentuate the black and white elements of which they are formed on the grey, and the white details on the black checkings; whereas threads (*b*), in the warping and wefting, though composed of the same shade ingredients as (*c*), merely develop a neutral grey tone. From which it is evident that twist yarns preserve their composite and individual qualities in the textural product; and, in so far as they accomplish this, they have both a colour and an effect value in the pattern. In the reversible texture, which is strictly a two-ply cloth, the fabric woven in the 4-fold linen yarns is spread over the texture woven in the twist yarn in the ground portions of the design, while the latter is brought on to the surface and the former taken on to the back of the structure, in sections A and in such parts of the style as the twist yarns are visible. The sectional plan—Fig. 101A—is illustrative of the weaving process. Threads and picks T represent the twist, and threads and picks 4, the linen yarns. In sections A the ends and shots 4 cover those lettered T, and in section B the ends and shots T cover those lettered 4.

130. *Clearness and Definition of Interlacing Details.*—The clear, pronounced details in the example are due to the formation of the twisted cotton yarns. There are, strictly, three varieties of structural effect, produced by (*a*) the twist-yarn colour composition; (*b*) the multi-folded threads; and (*c*) the build of the fabric. The first species of textural result is purely characteristic of twist yarns consisting of thread units in contrasting tones. The second—contrasts in yarn thicknesses—is restrictive to the combination of folded yarns differing in counts, as in the use, in Fig. 101, of the comparatively thick linen with the comparatively small cotton threads; and the third—contrasts in fabric fineness—arising from the interchanging from face to back, and conversely, of

the plain structures woven respectively in the twisted and the four-fold yarn.

FIG. 105

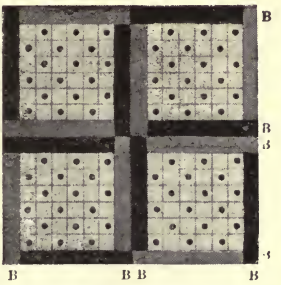


FIG. 105A

131. *Contrasts in Folded-Yarn Counts.*—Contrasts due to differences in yarn counts have been referred to, but not as a principle of pattern origination in which sense it will now be more particularly illustrated and explained. Apart from the effects acquired in the cloth by tinting the single threads of the compound yarn differently as in specimen 100, the assortment, in the warping, wefting, or both, of multi-fold yarns in one colour is a weaving practice applicable to the design and construction of cotton and linen, worsted and cotton, and other classes of union fabrication. A useful scheme, capable of elaboration in the sorts of yarn combined and also in design style, consists in grouping fine counts of

FIG. 106

2-fold with heavier counts of several-fold yarn, in the construction of a double-weave cloth. Using the looming arrangement sketched in Fig. 101A, either section A or B might be selected for the ground or figured portions of the pattern, but in any case the two weaves would be worked into the weaving plan as shown. Obviously they may be arranged on a striped, checked or decorative base. The checked form is exemplified in Fig. 102, the design being composed of 24 ends and picks of the weave in section A Fig. 101A, and of 8 ends and picks of section B ; while the yarn classification for the warping and the shuttling is as follows—

24 Threads { 1 thread of (*a*) 5-fold 12's cotton.
3 threads of (*b*) 2-fold 64's linen.
1 thread of (*a*)
1 ,, (*b*)
2 threads of (*c*) 2-fold 40's coloured cotton.
1 thread of (*a*)
2 threads of (*c*)
1 thread of (*b*)

132. *Prominence and in relief character of Fabric Elements Woven in Multi-Fold Yarns.*—Multi-fold threads protrude on the face of the fabric and impart character and tone to the textural effects. At the same time they also impart a degree of hardness of handle to the cloth, which, in linen and cotton unions, is not ordinarily considered an undesirable property ; but when the finer or foundation yarn is worsted, or woollen, the somewhat inflexible quality of the compound folded yarn is moderated by reducing the measure of twine in the single threads of which it is made, and also in the multiply structure in the twisting operation. This method of improving the feel of the fabric is practised in the production of small and intermingled textural types of the description illustrated in Fig. 103. Here the plan is that printed in Fig, 103A ; and, in the weaving of the fabric, woollen threads are combined with folded cotton threads in the following order—

Warp.

1 thread of 3-fold 5's cotton (loosely twisted).
2 threads of 10 skeins woollen (dark shade).

Weft.

1 pick of 3-fold yarn, namely 1 end of 15 skeins woollen twisted with 1 end of 5's cotton, retwisted—in a reverse direction—with 1 end of 15 skeins woollen.
4 picks of 10 skeins woollen.

It is not in this, and like groups of fabric, a question of a change in weave—the principle of combining the common and open plain makes of texture being observed as in Fig. 100A—but a question of modifying the formation of the thick thread, which is evident in its loosely-twisted condition in the warp, and in its unification with the woollen yarns in the warping and wefting.

FIG. 107

133. *Yarn Doubling and Pattern Origination.*—The three-fold weft, in this example in two shades—the woollen a dark and the cotton a light tone—dots or specks the ground of the pattern, and suggests the diversity of style possible as a consequence of comprising, in the folded yarn, single threads differing in tint or colour. Several-ply threads, when thus constructed, are of primary value in textural work, yielding a species of design which is based upon facility and ingenuity in yarn production. The mere doubling of a thick counts of thread with a single

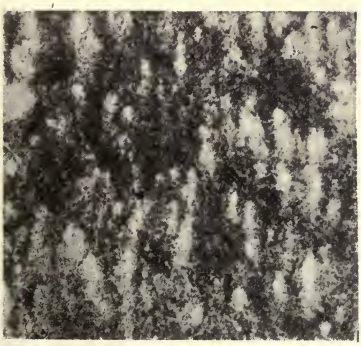


FIG. 108

thread of another colour means a source of woven pattern. Figs. 104 and 104A demonstrate the nature of the effects thus obtainable. A 2-fold 6's cotton is, in these union specimens, slackly twisted with a single 30's coloured thread, the ground of the textures being woven in 2-fold 80's linen for warp and 40's linen for weft, with tinted cotton yarns for the checking lines. The folded yarn is now seen to have a double value in the cloth, that of the contrasts originated by a difference in yarn counts, and that due to the particles of colour distributed on the circumference of the thread. By mechanically varying the system of twisting, the single but coloured threads may be grouped, in the making of the compound yarn, to form on its surface chain, diamond, and other simple geometrical features. These give, in the texture, a rich variety of pattern elements. The use of light and dark-toned threads, folded together on this principle, may first be examined. The specimens submitted for analysis, Figs. 105 and 106—Plan, Fig. 105A—have been acquired in the following weaving data—

SPECIMEN.—Fig. 105; Plan, Fig. 105A

Warp.

1 thread of (*b*) black and white twist; composed of 1 lapping—2-fold 60's white cotton—thread, twisted with a black and white thread, formed of 1 end of 2-fold 60's cotton and 8 ends of 2-fold 36's worsted.
6 threads of (*a*) 2-fold 36's black worsted.
2 ,, (*b*)
6 ,, (*a*)
1 thread of (*b*)
1 ,, (*c*) black worsted, composed of 8 ends of 2-fold 36's.
6 threads of (*a*)
2 ,, (*c*)
1 thread of (*a*)
4 threads of (*d*) 60's, 2-fold white silk.
1 thread of (*a*)
2 threads of (*c*)
1 thread of (*a*)
4 threads of (*d*)
1 thread of (*a*)
2 threads of (*c*)
6 ,, (*a*) *Weft* same as *Warp*.
1 thread of (*c*) 36 ends and 34 picks per inch.

SPECIMEN.—Fig. 106; Plan, Fig. 105A

Warp.

1 thread of (*b*) folded twist yarn, composed of 8 threads of 40's worsted, twisted—left-hand twine—with 2 threads of 60's 2-fold silk, and the latter re-twisted—right-hand twine with 2 threads of 60's 2-fold silk to form the chain effect.
6 threads of (*a*) 2-fold 40's worsted.
1 thread of (*b*)
1 ,, (*c*) 8-fold 2/40's worsted, equivalent to a 16-fold yarn.
6 threads of (*a*)
1 thread of (*c*)
1 ,, (*b*)
6 threads of (*a*)
2 ,, (*b*)
6 ,, (*a*)
1 thread of (*b*)
1 ,, (*c*)
6 threads of (*a*)
1 thread of (*c*)
1 ,, (*b*)
6 threads of (*a*)
1 thread of (*b*)

18 threads { 1 ,, (*c*); 2 threads of (*a*); 2 ,, (*d*); 2 ,, (*a*); 1 thread of (*c*) } doubled 60's 2-fold silk.

Weft same as *Warp*.

18's reed 2's; 34 picks per inch.

134. *Diamond and Chain Twist Specimens.*—The extent to which twist yarns may be doubled and re-doubled and rendered texturally effective in this process, is typified in these examples. The ground warp and weft—threads (*a*)—are 2-fold 36's and 2-fold 40's worsted in Figs. 105 and 106 respectively. Yarn (*b*), in both specimens, has a foundation structure of 8 threads of worsted, which is twisted, in the first operation, with a white cotton or silk thread, and, in the next operation, it is reverse twisted with a second cotton or silk thread, for producing the interlacing or chain lines, in white, on the

multi-stranded worsted yarn. Union thread structure, as formed and developed in folding, is the technical basis of this class of manufacture. Cotton, as well as worsted, may be used for the foundation yarn, but it should be a soft and not a normally twisted thread, otherwise the fabric becomes hard and unyielding in the handle and unsatisfactory in the wear. The chain-like demarcations on the surface of such multi-folded

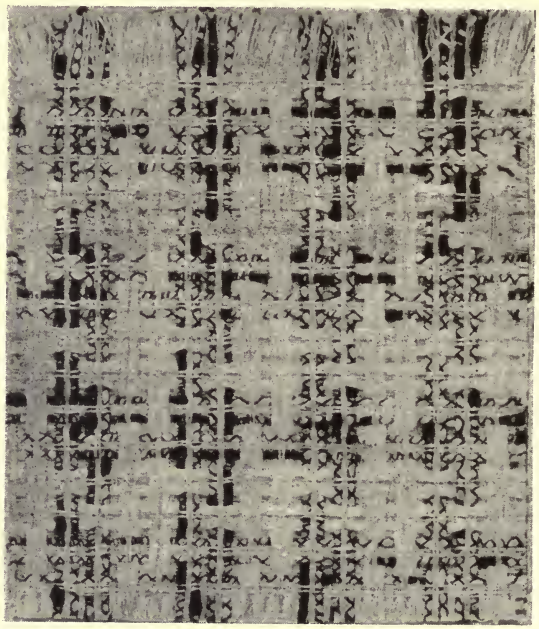


FIG. 109

yarns, are invariably obtained by employing two small ends wrapped in reverse directions, round a thicker or central thread. The small ends may lap with the latter at different angles, forming either a collapsed or elongated chain or diamond device. With the colours of the binding and staple threads in contrasting tones, the effects, as seen in Figs. 105 and 106, are clearly delineated in the texture. The intersection of the warp and weft at right angles with each other, causes the compound-yarn elements to be variously but evenly distributed

on the face of the cloth; while the plan, Fig. 105A, regulates and determines the pattern scheme in combination with the arrangement of the yarns in the warping and shuttling. The ground of the weave design is plain woven, but threads and picks (B) float alternately on the face and back of the fabric, in the warp over seven picks, and in the weft over seven threads, making in reality a check design. The method of yarn classification, in the use of twists thus varied in thread counts and quality, is an essential part of the designing practice. Each type of thread is located in the warp and weft for giving a special textural property and effect, as in these specimens, in which the 2-fold worsted yarn is applied to the ground of the cloth; the threads (*b*) to the formation of the distinctive elements in the style; and threads (*c*) to the weaving of the star details and overchecking lines. The percentage of each class of fibre, of which the yarns are composed, is also taken into consideration, but it is secondary to pattern origination as producible by the single and multi-folded yarns, combined in relation to the development of a particular variety of pattern in a given make of manufacture.

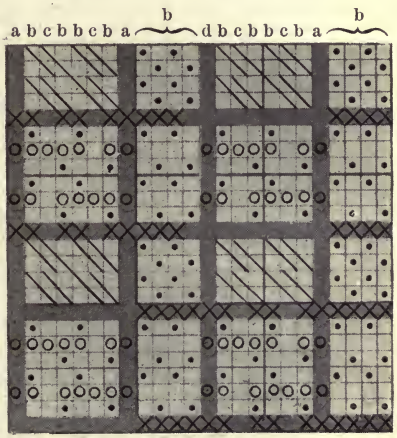


FIG. 109A

135. *Specked and Spotted Yarns.*—Spotted yarns should be distinguished from flake, cloud, and knop twisted threads. The spotted or specked feature is producible in two ways—in the treatment or preparation of the materials of which the yarns are made, and in the twisting of two or three threads into a folded yarn structure. The first practice gives a spotted but single-spun yarn, and consists in depositing neps of cotton fibre on to the carded material as it passes over the last cylinder

of the carding machine. Unopened clusters of filament thus pass into the condensed sliver and become part of the spun yarn, which they speck with white or colour but at irregular intervals. The folded spotted thread is developed in the twisting frame. The specked features may, on this principle, be regulated in size and in a degree in shape, and be also evenly distributed throughout the length of the yarn. Cotton and worsted, mohair and cotton, silk and cotton, and cotton and

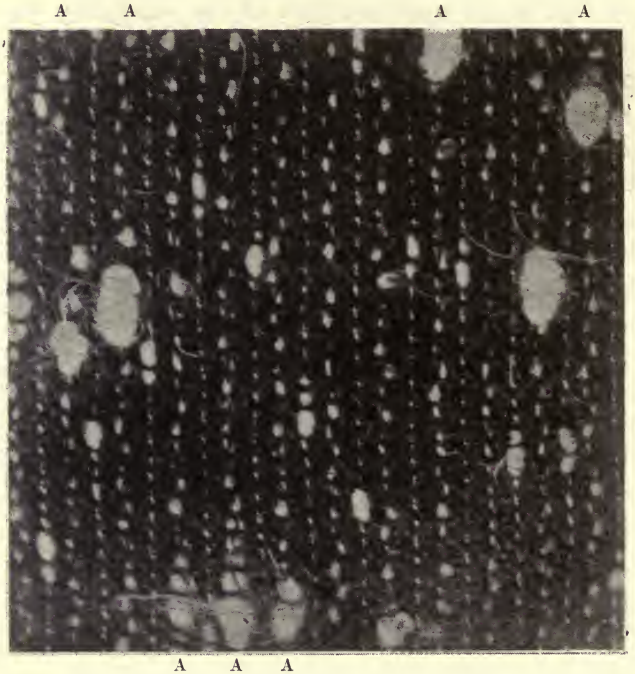


FIG. 110

linen threads are combinable in this form. Such twists are usable as the warp and weft yarn of the fabric, but, in the ordinary grades of manufacture, their application is restricted to forming sectional parts of the warping and wefting scheme. Fig. 107 is suggestive of the piece-dyed costume make of texture with the spotting threads inserted in the warp, which is arranged 23 threads of 2-fold 32's worsted and 1 thread of

specked twisted, and yarn made by folding one end of 40's worsted with a cotton sliver and then lapping with a single end of 60's worsted. The weft is 22 skeins woollen and the cloth is slightly felted and raised. To attain, however, the full advantage of felting and raising in the finishing of the fabric,

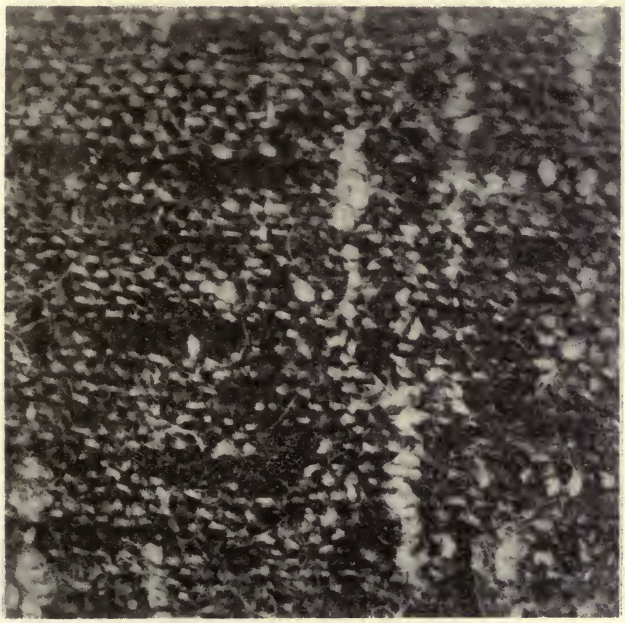


FIG. 111

the fibre selected for spotting purposes should be wool or mohair and not of the vegetable character. This provides an adaptable quality of filament in the spotting for effective raising action as is observed in the specimen, Fig. 108, woven in the 2-and-2 twill, and with the yarns formed and grouped in accordance with the particulars specified below—

Warp.

1 thread of spotted twist yarn, composed of 1 end of 30's worsted (soft spun) twisted with 1 end of 40's cotton, and retwisted with 1 end of 40's worsted.

4 threads of 2-fold 28's worsted.

17½'s reed 2's.

Weft.

14's worsted or 30 skeins woollen. 27 picks per inch.

136. *Duplicating Spottings and Colourings.*—The spots may be duplicated in colour as well as varied in the distance apart and in form. The double spot and also the double knop yarn are both produced, in their simpler types of construction, by using two ground or core threads and two lapping ends: *e.g.*, two worsted central ends spotted successively with cotton and silk, or a doubled yarn spotted with two colours of cotton yarn. The ground threads, in more diversified structures, are variously constituted, and, in the instance of the knop, the spaces between the spottings may be chain twisted, as in the example in Fig. 109, in which the knopped cotton twists are 6-fold in the foundation and specked, in the actual texture, alternately with orange and black as indicated in the order of warping and wefting appended :—

SPECIMEN.—Fig. 109; Plan, Fig. 109A

Warp and *Weft.*

24 Threads	1 thread of	(*a*) 6-fold 26's cotton spotted with 40's orange and 40's black cotton ends.
	1 ,,	(*b*) 2-fold 160's linen.
	1 ,,	(*c*) 40's 2-fold silk.
	2 threads of	(*b*)
	1 thread of	(*c*)
	1 ,,	(*b*)
	1 ,,	(*a*)
	4 threads of	(*b*)
24 Threads	1 thread of	(*d*) 6-fold 26's cotton.
	1 ,,	(*b*)
	1 ,,	(*c*)
	2 threads of	(*b*)
	1 thread of	(*c*)
	1 ,,	(*b*)
	1 ,,	(*a*)
	4 threads of	(*b*)

18's reed 3's. 54 picks per inch.

137. *Specimen in Folded Cotton and Linen and Doubled Silk Threads.*—Though the fabric is composed of linen, cotton and silk, the textural quality and effect are principally derived from the knopped and 6-fold yarns, arranged with a view of developing a checked style. The chain twist elements and the

spottings in the two tints of cotton on threads (*a*) add to the quality of the textural plan, especially in contrast with the finer features woven in plain and in more open interlacings, and formed in the linen and silk ends and picks. The weave design, Fig. 109A, in this class of fabrication requires to be contrived on such a principle as to suitably emphasize each type of yarn in the warp and weft, and as to result in a satisfactory or uniform build of cloth. First, in this illustration, threads (*a*) are brought on to the face of the texture in symmetrical order and equally with threads (*d*), as both are of like utility in producing the checking lines; second, the silk threads and picks are made to float over the twist and folded yarns, imparting brightness of tone; and, third, the linen threads (*b*) are interlaced plain to form a firm foundation structure.

FIG. 112

FIG. 113

138. *Mohair and Lustre Materials in Knopped Yarns.*—With the knopping yarn consisting of a diffusive kind of material such as mohair, the spotting may be made a pronounced feature of the pattern, as in threads A of the specimen in Fig. 110, which have been obtained by twisting a 20's black and 20's white cotton with a mohair sliver intermittently delivered. The ground threads pass, in the making of the yarn, between one pair of rollers in constant operation, and the knopping thread

between a pair of rollers, having an intermittent and differential motion, for giving the smaller and larger spotted excrescences in the length of the folded yarn. When this system of knop thread construction is adopted, it is practicable to have the knopped characteristics short, compact and bulky or more or less pear-shaped, with thin strands of knopping fibre running through the whole length of the twisted thread. The form of the knop, beyond keeping it within certain length limits, is not precisely definable, but this only adds to the diversity of the effects acquired in the woven specimen. Even when there is little change in colouring, as, for example, in a black core yarn with white knopping, and this in mohair on a woollen or worsted thread, the knops appear in the texture in a number of forms, enhanced in quality and distinctiveness by the contrast in the natural properties of the two varieties of fibrous material combined.

FIG. 114

139. *Rougher Grades of Fabrics and Multi-ply Union Threads.*—The examples so far examined have been chiefly confined to textures made of the smaller counts of yarn, and in which the materials are characteristic of the smoother and finer classes of textile manufacture. In the rougher grades of fabric more varied combinations as to yarn structure are feasible, or, at least, combinations of threads of a more mixed filament composition and nature. Folded union yarns of the knopped, buckled, looped, flaked and even curled description, are applied in a diversity of forms to fabrics of the Cheviot and Crossbred yarn quality. These give a textural surface which admits of specific and complex treatment as to yarn factors as instanced in the styles in Figs. 111 to 114, which

are representative of the makes of fabric and types of pattern obtained in manufactures of a medium weight per yard, and produced in open settings and in the plain weave.

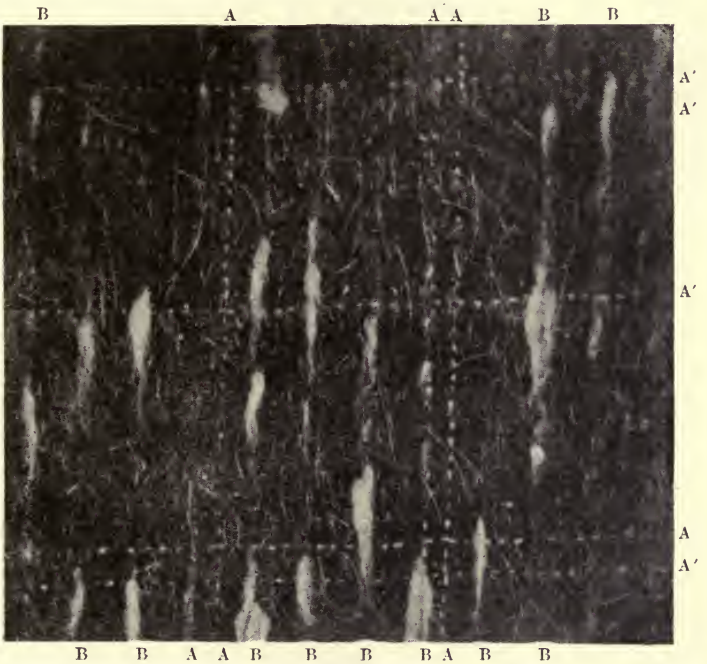


FIG. 114A

SPECIMEN, Fig. 111

Warp.

3 threads of (*a*) black and brown twist yarn, composed of 1 end of 2-fold 32's cotton twisted with 1 end of 9's mohair, and re-twisted with 16's black cotton.

1 thread of (*b*) black and white mohair knop twist yarn, composed, in the first operation, of 1 end of 2-fold 20's black mohair twisted with 1 end of 2-fold 20's white mohair; and re-twisted, in the second operation, with 1 end of 2-fold 20's black cotton and 1 end of 18's white cotton.

4 threads of (*a*); 1 thread of (*b*); 6 threads of (*a*); 1 thread of (*b*); 8 threads of (*a*); 1 thread of (*b*); 10 threads of (*a*); and 1 thread of (*b*).

7's reed 2's.

Weft.

Same as *Warp*, but using 8 skeins grey mixture yarn instead of the 4-fold black and brown twist (*a*).

12 picks per inch.

SPECIMEN, Fig. 112

Warp.

8 threads of (*a*) 17 skeins light grey woollen.

1 thread of (*b*) black and white knop twist yarn, composed of 1 end of 2-fold 30's black cotton, 1 end of 2-fold 26 skeins white woollen and 1 thread of 2-fold black cotton for lapping or binding.

8's reed 2's.

Weft.

18 skeins dark green mixture.

16 picks per inch.

SPECIMEN, Fig. 113

Warp.

1 thread of (*a*) black and white knop twist yarn, composed of 1 end of 2-fold 28's black crossbred worsted, twisted with 1 end of 2-fold 60's black cotton and 1 end of 2-fold 28's white crossbred, and lapped with 1 end of 30's black cotton.

3 threads of (*b*) 10 skeins grey woollen; 1 thread of (*a*); 5 threads of (*b*); 1 thread of (*a*); 4 threads of (*b*); 1 thread of (*a*); 3 threads of (*b*); 1 thread of (*a*); 8 threads of (*b*).

8's reed 20's.

Weft.

1 pick of (*a*) black and orange knop twist yarn, composed of 1 end of 2-fold 28's orange crossbred worsted, twisted with 1 end of 2-fold 60's black cotton and 1 end of 2-fold 28's black crossbred, and lapped with 1 end of 30's black cotton.

5 picks of (*b*) 12 skeins fawn woollen; 1 pick of (*a*); 3 picks of (*b*); 1 pick of (*a*); 10 picks of (*b*); 1 pick of (*a*); 3 picks of (*b*); 1 pick of (*a*); and 6 picks of (*b*).

17 picks per inch.

SPECIMEN, Fig. 114

Warp.

1 thread of (*a*) black and white knop twist yarn, composed of 1 end of 2-fold 60's black cotton, twisted with 1 end of 2-fold 36's white crossbred worsted, and re-twisted or lapped with 1 end of 26's black cotton.

7 threads of (*b*) 7 skeins light grey woollen.
4 „ (*c*) 7 „ dark „
4 „ (*b*)
4 „ (*c*)

6's reed 2's.

Weft.

11 skeins black woollen.

14 picks per inch.

140. *Mingled and Mottled Colour Toning.*—Mingled and mottled colour toning is a primary characteristic of these multi-fold yarn patterns, with a mosaic fibrous species of effect as a distinctive ingredient. This varied textural surface is not producible in any other scheme of loomwork than that here illustrated. It is, moreover, a pure production of the combination of textile factors, being solely dependent upon the method of forming the compound yarn and of associating this with other yarns in the weaving of a definite grade of fabric. All such effects are peculiar to the sorts of fibre used in the preparation of the individual threads in the twisted yarn compound, and to the form or forms in which they are doubled and re-doubled to comprise one description of weavable thread. Design in the loom is not restricted to the interlacing of warp and weft in the origination of a prescribed build of cloth and style of pattern. It extends to the study of the pattern types obtainable in the admixture of fibres of different physical structures and chemical properties, in the construction of the yarn, and in the modification of the surface of the thread, in the practice of folding and twisting. Thread formation, when thus devised, has a tinted, structural, and utilitarian value in the woven manufacture.

141. *Folded Union Yarn Structures and Piece Dyeing.*—The spotted and knopped yarns analysed have been treated as prepared in the tints and tones in which they were applicable to the fabric, and to the development of specific varieties of textural effect; but such yarns, when made of thread units differing in filament composition, are producible in the grey and usable in this condition for piece-dyed goods. This

introduces a technical quantity which provides for colour modification in the manufactured fabric. It is based on the employment, in the warping and wefting, of compound twist threads with single-spun, plain folded, and bi-fibred yarns, of identical tinting properties. To illustrate, the raised knopped-yarn specimen in Fig. 114A is a combination of worsted warp and fine woollen weft in the ground, of worsted and cotton twist threads A, A′, and of the knopped threads B, consisting of two ends of worsted twisted with a ramie roving intermittently delivered in the folding process. Weaving in the grey, and wool dyeing the texture black, develops the woollen and worsted ingredients in the dark shade, the twist threads and picks in black and white, and leaves the ramie knops of fibre untinted or in a light tone. The extent to which this scheme of work is practicable, in the use of fancy union yarns, is further exemplified in the decorative tapestry photographically illustrated in Fig. 115. It has been made in a 2-fold 20's cotton warp—concealed in the texture by combining two weft-face reversible weaves—and in single woollen and thick cotton twist wefts, shuttled one-and-one. The knop, gimp, and minute curl features in the twist threads, are formed of mohair and worsted yarns, so that in wool dyeing, as seen in the specimen, they take the same colour as the woollen weft, while the cotton-thread units remain uncoloured. If the piece should be cotton-dyed, the colour tones in the fabric would be reversed, that is to say, the woollen, worsted, and mohair effects would continue white as woven, and the cotton effects would become coloured. By tinting each kind of fibre in the multi-fold and in the ordinary spun yarns, or by practising both wool and cotton dyeing, the diversity of coloured result in the finished manufacture, would be considerably enhanced. But, as the designs applied to this class of tapestry should be of an ornamentative character, and as the fabric structure is framed on the reversible principle, it is only necessary, as a rule, to practise single-process dyeing. The important technicality in such branches of textile manufacture

Fig. 115

obtains in the origination and construction of the multi-ply twist yarn. This yarn is the chief source of the acquirement

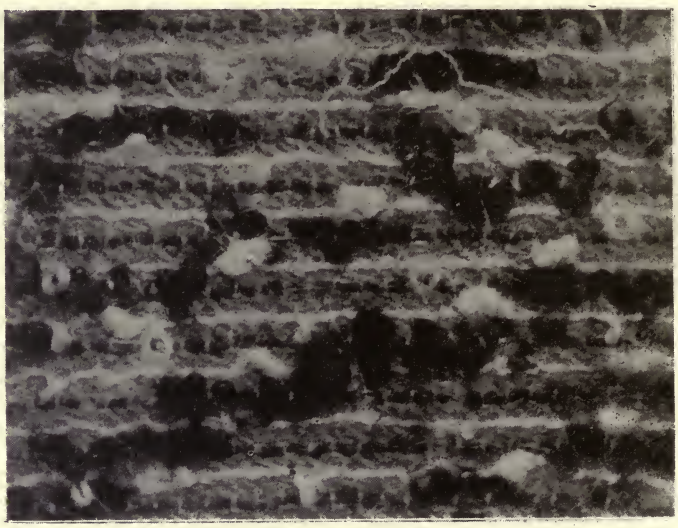


FIG. 116

of fulness of textural detail, and of variations of effect in the design scheme.

142. *Curl Yarns.*—The "curl" is a different form of union twist to that of the "spot," "knop," or "flake." Ordinarily it is a three-strand yarn, such as two cotton and one worsted, or two worsted ends twisted with a thicker and softer spun thread for the curl or loop. These curly excrescences, in the circumference of the folded structure, vary in dimensions and in the frequency with which they occur in the length of the twisted yarn. They are preferably made of mohair or lustre worsted. On whatever principle such yarns are applied in the weaving process, they give the characteristic feature to the fabric. In the heavier grades of cloth—mantles, cloakings—the curl yarn, as in woven astrakhans, forms the

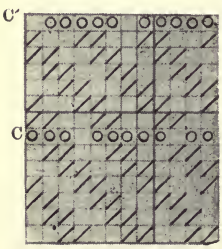


FIG. 116A

face of the texture, but in the thinner classes of goods, it is principally used for its pattern-producing qualities. It is in the latter sense that it is inserted into the weft of the specimen in Fig. 117. This fabric is woven in a 2-fold 20's worsted warp, with 44 ends per inch, and in the plan, Fig. 117A. The weft consist of 6 picks of 2-fold 40's worsted, 1 pick of curled yarn, *c*—composed of two ends of 24's black mohair twisted with 2-fold 40's black cotton—6 picks of 2-fold 40's worsted, and 1 pick of curl yarn, *c'*, resulting from twisting two ends of 20's white mohair with 26's white cotton.

143. *Finishing Practice and Fancy Folded Yarn Effects.*—Finishing methods and practice as they relate to curl-yarn fabrics, and to the effects obtained in union fancy yarns made of cotton, linen and silk, are intended and designed to cleanse the piece, level the textural surface, and to brighten the colour tone. But, in the combination in the fabric of knop and similar sorts of yarn, formed of woollen, worsted and mohair threads, the finishing sequence may be adapted to modify the twist-yarn characteristics, subduing or intermingling their tinted qualities. Examples, in which milling and raising have attained these results, are given in the specimens in Fig. 108 and 114. What, prior to the finishing operations, were merely spotted or specked details of material, have, in the raising, been changed into intermixed, elongated and streaky patches of white and grey fibre. Forming the knops in a more lustrous material, and in two sizes and at greater distances apart, as in Fig. 114A, and subjecting the piece to the action of the raising points of the raising machine, again disintegrates their original form and consistency, and mingles the filament, of which they are made, with that in the ground of the fabric.

SECTION III

WOVEN UNIONS

CHAPTER VIII

LOOMING PRINCIPLES

144.—Tinting Practice and Bi-fibred and Woven Unions. 145.—Classification of Yarn-Woven Unions. 146.—Yarn Admixtures in the Warping and Wefting. 147.—Yarn Diameters in Admixed-Yarn Fabrics. 148.—Structural Examples. 149.—Rendering One Series of Yarns invisible in the Cloth. 150.—The Weft Unit. 151.—" Weave" Method of Concealing either the WARP or WEFT Threads. 152.—Specimens in WARP and in WEFT Effects. 153.—Design Composition for WEFT Scheme. 154.—Converting Weaves into WARP or WEFT Plans. 155.—Patternwork in WARP- or WEFT-face Unions. 156.—Manufacturing Data—Piece-dyed and Loom-coloured Unions. 157.—Three Systems of Construction. 158.—Methods of Emphasizing Weave Details. 159. — Yarn " Twine " and Union-Twill Movement. 160.—Effect of " Twine " Direction in the Yarn in Union Textures. 161.—Tone Differentiation in Dyeing due to Yarn Twine and Structure. 162.—Experimental Schemes. 163.—Curtailment of Weave Diversification. 164.—Utility of Yarn Quality and Structure in Design delineation. 165.—Raising Action and Design Quality. 166.—Warp Scheme of Fabrication. 167.—Ornamentative Style Origination. 168.—Weave Elements and Pattern Values. 169.—Bi-fibred and Single-quality Yarn Schemes.

144. *Tinting Practice and Bi-fibred and Woven Unions.*—Dyeing efficiency, in developing diversity and newness of effect in bi-fibred fabrics, has been shown to be based on two compound factors—first, the technology of thread preparation as determined by the filament ingredients combined, whether in the work of spinning, or in the system of yarn doubling and twisting ; and, second, the technology of fabric construction as understood, and comprised, in the assortment and grouping of yarns of a suitable structure, for producing special grades and qualities of textile manufacture.

The union cloth industry is not infrequently interpreted as signifying fabrics consisting of two or more varieties of yarn, as, for example, the warp thread made of vegetable

fibre, and the weft thread of animal fibre ; or the warp yarn differing in filament composition from the weft yarn. The woven goods obtained by these practices are notably dissimilar in principles of fabrication and in dyeing properties from those described as resulting from yarns in which the fibrous units are blended prior to spinning, or unified in the spun

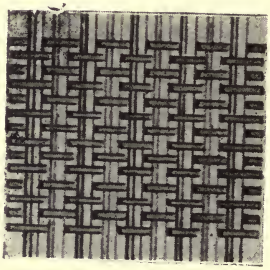


FIG. 117

FIG. 117A

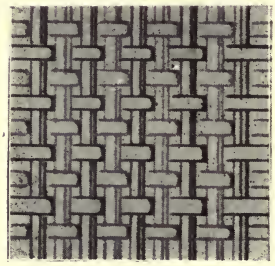


FIG. 117B

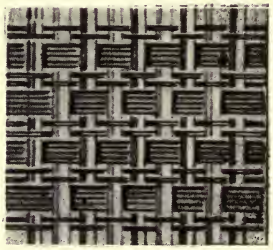


FIG. 117C

state, as in the origination of multi-fold threads. In the yarn-made union each class or type of yarn amalgamated is, as a rule, susceptible to one routine of dyeing treatment, yielding one tone or tint of colour ; whereas, in the admixture of several sorts of fibre in yarn production, each thread in the piece may be as variously coloured as the kinds of material employed in its manufacture. The distinctions between the fabric made of yarns composed of a number of separate classes

of fibre, and the fabric made of cotton or linen, and mohair, worsted, woollen and silk yarns are, therefore, as regards dyeing results, fundamental in character. One manufacture derives, in piece-dyeing, its tinted value from the diversified filament structure of each yarn used, and the other from differences in the fibrous materials of the yarns in the warp and the weft of the cloth, as in the combination of cotton and woollen, linen and silk threads, etc.

145. *Classification of Yarn-Woven Unions.*—Union fabrics of the yarn-woven variety include three principal groups of textile manufacture, namely, (1) Textures in which the yarns, warp or weft, spun of the vegetable fibre are interlaced in the foundation or body of the cloth, being hidden or concealed in both the face and underside of the fabric ; (2) textures in which each class of yarn employed appears on the surface with one species of yarn giving the fabric quality ; and (3) textures compound in build and in which one series of yarns produces the right side, and a second series of yarns the reverse side of the cloth ; or in which three sets of yarns are woven together and respectively form the face, centre, and back of the manufacture. These three types of union production are sub-divisible into the following categories—

TABLE XIX.

CLASSIFICATION OF YARN-WOVEN UNIONS

GROUP I.

(*a*) Union woollens, chiefly produced in medium and heavy grades of cloth, but also in costume and flannel fabrics.

(*b*) Union worsteds, chiefly produced in medium and light textures.

(*c*) Overcoatings and milled cloths, single in structure.

(*d*) Curled and frisé fabrics, single or compound in structure, with mohair, worsted, and woollen weft.

(*e*) Blankets, rugs, and shawls.

(*f*) Linen and cotton unions—simple weave construction.

(*g*) Cotton and silk unions—simple weave construction.

(Cotton warp and woollen or worsted weft yarns, are used in Classes (*a*), (*c*), (*d*), and (*e*), and worsted or cotton warp with cotton or worsted weft in Class (*b*).

GROUP II.

(*a*) Dress and blouse fabrics, cotton warp, and mohair, lustre worsted, or alpaca weft.
(*b*) Dress and figured fabrics, cotton warp and silk or artificial silk weft.
(*c*) Figured linen-warp and cotton-weft manufactures.
(*d*) Figured linen- or cotton-warp and silk-weft manufactures.
(*e*) Cotton warp and weft textures, with silk figuring warp or weft.
(*f*) Linen warp and weft textures, with silk figuring warp or weft.
(*g*) Cotton warp, worsted or woollen weft, and silk as the extra yarn for spotting or figuring.

GROUP III.

(*a*) Fabrics two-ply in the weft:-Worsted warp, and cotton and woollen yarns for shuttling.
(*b*) Fabrics two-ply in the weft:-Cotton warp, and worsted and woollen yarns for shuttling.
(*c*) Fabrics two-ply in the warp:-Worsted or woollen warp, and cotton weft.
(*d*) Fabrics two-ply in the warp-:Worsted face and cotton backing yarns with woollen weft.
(*e*) Fabrics two-ply in both warp and weft:-Face warp, worsted or woollen; backing warp, woollen or cotton; face weft, worsted or woollen; backing weft, cotton or woollen.
(*f*) Three-ply weft fabrics: Cotton warp; face weft, worsted or woollen; centre weft, cotton; backing weft, woollen.
(*g*) Three-ply warp and weft fabrics: Face warp and weft, worsted or woollen; centre warp and weft, cotton; backing warp, worsted or woollen; backing weft, woollen or cotton.

146. *Yarn Admixtures in the Warping and Wefting.*—Each of the classes of manufactures specified in Groups I, II and III, is subjective to variations in looming. There are, in addition, intermediate qualities and makes of texture acquired by warping and wefting two or three sorts of yarn in successive order, as one thread of cotton and one thread of woollen, worsted or mohair; one thread of linen and one of cotton; two of worsted and one of silk or mercerized cotton; and one of cotton and one of silk. Yarn admixtures of this description are practised in both single and compound weaves, and result in fabric types of ordinary application but not strictly covered in the Group classes defined.

The following are examples in looming arrangements—

TABLE XX

YARN ADMIXTURES IN LOOMING—SIMPLE-WEAVE CLOTHS

I.—COTTON AND LINEN

System A.

Warp.	*Wefts.*
1 or 2 ends of cotton	(1) Cotton, (2) Linen, (3) Same as warp
1 or 2 ,, linen.	(4) Fine woollen or worsted.

System B.

Warp.	*Wefts.*
1 end of linen	(1) Linen, (2) Cotton, (3) Same as warp.
2 ends of cotton	(4) 2 picks of linen and 1 pick of cotton.
1 end of linen	(5) 2 picks of cotton and 1 pick of linen.
1 ,, cotton	(6) Fine woollen or worsted.
2 ends of linen	
1 end of cotton.	

II.—WOOLLEN OR WORSTED AND COTTON

System A.

Warp.	*Wefts.*
1 end of woollen or worsted	(1) Woollen or worsted, (2) Same as
1 ,, cotton.	warp.

System B.

Warp.	*Wefts.*
2 ends of woollen and worsted	(1) Woollen or worsted, (2) 1 of woollen
2 ,, cotton.	and 1 of cotton, (3) Same as warp.

System C.

Warp.	*Wefts.*
1 end of worsted	(1) Worsted, (2) 1 of worsted and 1 of
1 ,, cotton	cotton, (3) Same as warp.
2 ends of worsted	
1 end of cotton	
1 ,, worsted	
1 ,, cotton	
1 ,, worsted	
2 ends of cotton	
1 end of worsted	
1 ,, cotton.	

III.—LINEN, COTTON AND SILK

System A.

Warp.	*Wefts.*
1 end of linen	(1) Linen, (2) Cotton, (3) Silk, and
1 ,, silk	(4) Same as warp, (5) Worsted.
1 ,, cotton	
1 ,, silk.	

System B.

Warp.	*Wefts.*
1 end of cotton or linen	(1) Cotton, (2) Linen, (3) Silk, (4) Same
1 ,, silk.	as warp, (5) Worsted.

147. *Yarn Diameters in Admixed-Yarn Fabrics.*—The counts of the warp and weft threads in these systems of yarn admixture should, in the plainer styles of texture, be approximately uniform, but they may be also diversified for the purpose of obtaining a particular variety of cloth. Employing, for example, in System A, Class I, small and thick weft yarns result in fabrics of the formation sketched in Figs. 117 and 117A, that is of textures ribbed in the warp and in the weft respectively. Wefting the yarns as warped gives a minute checked effect, Fig. 117B, and wefting one pick of thick yarn and two picks of small yarn produces a cloth lined or striped across, Fig. 117C. Altering the counts of the warp threads, or arranging the threads one of thick and one of small yarn, and wefting first, in fine, yarn counts; second,

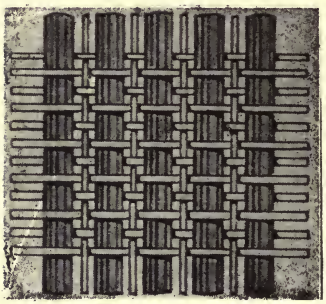


FIG. 118

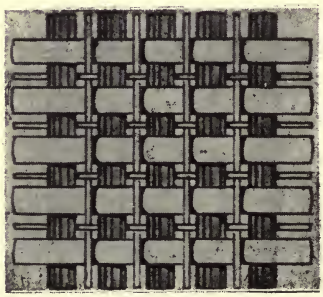


FIG. 118A

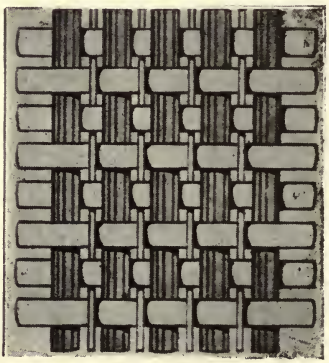


FIG. 118B

in the same yarns as in the warp ; and third, in thick yarn, yields the three descriptions of cloth in Figs. 118, 118A, and 118B ; namely, a warp-stripe, a small-check, and a suppressed warp-line textural effect.

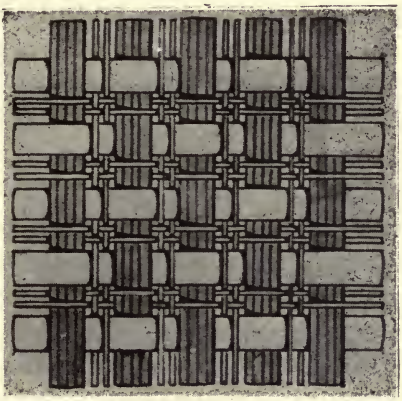


FIG. 119

Two further modifications in fabric structure, as originated by varying the warping and wefting plan, and by mixing yarns of different thicknesses are shown in Figs. 119 and 120. Combining small with thick threads, grouped two of the former to one of the latter, is seen, in Fig. 119, to make a species of checking, while the combination of three diameters of yarn, Fig. 120, produces an intermingled woven surface with each of the three threads—differing in thickness and in quality—crossing each other in a rectangular relation. Both these schemes would be shuttled, in the weaving of line pattern details, in each sort of yarn used in the warp.

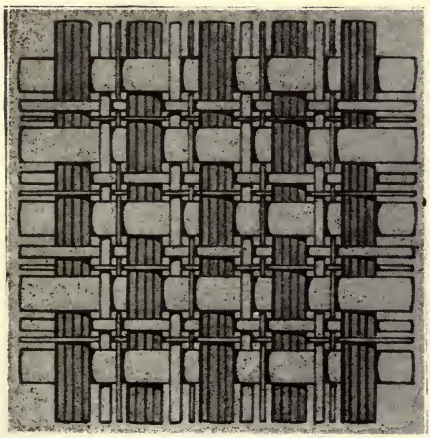


FIG. 120

148. *Structural Examples.*—The utility of changes of this nature in the yarn counts in the several systems of yarn grouping is exemplified in these sketches—Figs. 117 to 120—as resulting in woven structural types. They have also a value in modifying the proportionate

filament ingredients of the cloth. This is variable with the weft yarn selected, the relative counts of the yarns combined, and by the system of yarn arrangement. For instance in System B, Class I, with the weft same as the warp, and using linen and cotton threads of a like diameter, the fabric would consist of equal parts of flax and cotton fibre ; but with weft (1) the cloth would contain an excess weight of linen, and with weft (2) an excess weight of cotton yarn. Moreover, should weft (6) be selected a texture would be produced consisting of corresponding parts of linen and cotton in the warp, interlaced with a woollen or worsted weft yarn. Clearly, the filament values of the cloth are affected in a corresponding ratio with the counts of yarns used. Providing these are symmetrically classified in the warping and wefting scheme, and that the yarn counts coincide with each other, the filament quality of the cloth is determinable by the numerical classification of the different thread units combined.

149. *Rendering One Series of Yarn invisible in the Cloth.*— In the yarn admixtures analysed, each variety of thread, in the warp or weft, is intended to have a textural effect, but in the union fabrics included in Group I, Table XIX, the cotton, or vegetable-fibre yarn should, as far as possible, be rendered invisible in the finished manufacture. This is facilitated by using a thicker weft than warp yarn, by piece contraction in milling, and by employing a weave plan adapted for concealing the threads in the warp and for emphasizing the yarns in the weft of the cloth. But, in the production of certain classes of union woollens and worsteds, as the weave is either plain or an ordinary twill, it is a question of regulating the yarn counts, the setting, and the finishing practice, to accord with the development, from the yarn ingredients employed, of the character and nature of the cloth required. The construction of two examples of this category may be examined, that of A, a union costume fabric, and that of B,

a cotton-warp melton, and producible in the following weaving data—

A. *Warp.*—2-fold 40's cotton; 18's reed 2's; 70 in. wide in the reed.
Weft. —22 skeins woollen. 64 picks per inch.
Weave.—Prunelle twill, weft face.

B. *Warp.*—2-fold 24's cotton; 14's reed 2's; 76-78 in. wide in the reed.
Weft. —8 skeins mungo or low woollen; 40-44 picks per inch.
Weave.—$\frac{2}{2}$ twill, cutting 2's in the threads.

150. *The Weft Unit.*—The weft is the principal yarn factor in both these settings. Its increased thickness as compared with the warp yarn, plus the excess ratio of picks to threads—as 64 : 36 in A, and as 44 : 28 in B—has the effect of partially covering the cotton threads in the weaving, and of forcing them into the centre of the fabric structure. These conditions are augmented and made more or less permanent in the felting of pieces. In the process the costume cloth shrinks 16 in. and the melton 20 to 22 in. in width or from 70 and 78 in. in the loom to 56 in. milled. A nap of filament, formed entirely in the weft yarn, is developed, and in this nap the cotton ends are embedded. They are so perfectly covered as to be invisible and to be also almost imperceptible in the feel or handle of the cloth.

151. " *Weave* " *Method of Concealing either the Warp or Weft Threads.*—The " weave " method of concealing the cotton yarn in a woollen or worsted union, is not based on felting and raising technicalities, but on the system of intertexture practised. The problem is one of constructing a cloth presenting pattern features formed solely in the *warp* or in the *weft* yarn. Weaves of this description impose certain restrictions both in regard to fabric build and design development. Textural variations possible in the use of both warp and weft effects, are somewhat freely eliminated. These points will be evident on comparing the specimen in Fig. 121, woven in the plan given at Fig. 121A, with the modified weave structure—section in Fig. 121B—for obtaining a similar form of pattern in weft intersections so arranged as to cover and conceal the warp intersections in

the fabric. The white and light grey details in A and B of the texture in Fig. 121 consist of floats of warp, and the dark details of floats in weft. When both series of details are acquired in the warp only, the picks of weft lie intermediate

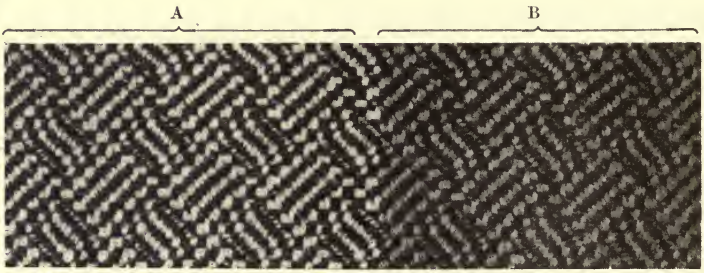


FIG. 121

between the floats of the warp ends, which are arranged one and-one in two colour tones; and, inversely, when the two qualities of effect are obtained in the weft only with the warp

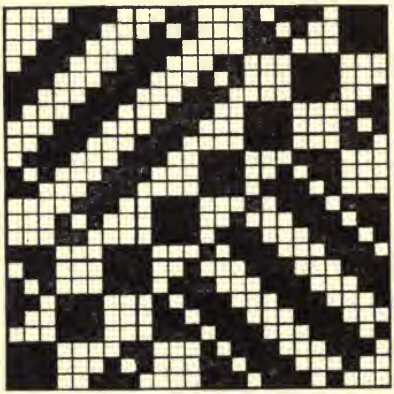


FIG. 121A

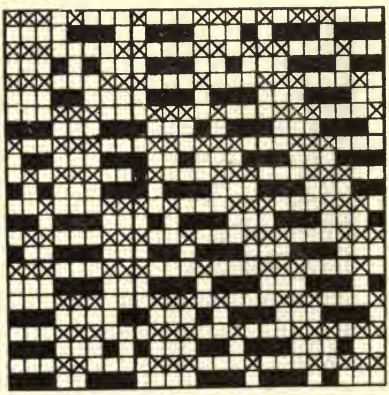


FIG. 121B

threads hidden, the latter lie intermediate between the shots of weft, shuttled one-and-one in two shades, or in two-yarn structures which, in the dyeing of the cloth, develop colour tones in contrast with each other.

152. *Specimens in Warp and in Weft Effects.*—The two

principles of intertexture are exhibited in the specimens in Figs. 122 and 123, woven in the ribbed or cord twills A and B, Fig. 124. Considering Fig. 122, the warp scheme, Plan A, Fig. 124, is warped end-and-end, dark and light shades, with the positions of the two colours interchanged as seen in the specimen. The weft is all one shade, and is all but concealed by the two sets of threads in the weave marked in ⊡'s and in ⊠'s. If the order of the shades in the warping were one dark and one light throughout, a twilled texture, as in stripings A, Fig. 122, would be acquired, but by transposing the grouping of the shades, *e.g.*, one light and one dark, and one dark and one light, in successive sections of 6 and 18 threads, a varied striped style is produced. The weave basis is that referred to in Paragraph 73, and is common in textural effects weavable in 1-and-1 warping, in which the weft is not a visible quantity in the fabric. This being so, the type of pattern sketched in Fig. 42 is likewise feasible in Plan A, Fig. 124, by arranging the warp one thread of a deep-toned and one thread of a lighter-toned yarn, and also in reverse order and in multiples of each order in accord with the divisional parts of the design in Fig. 43, the interchange of position of the two yarns, by their being thus combined, effecting equivalent alterations in the pattern scheme as the changing of the threads in the weave unit.

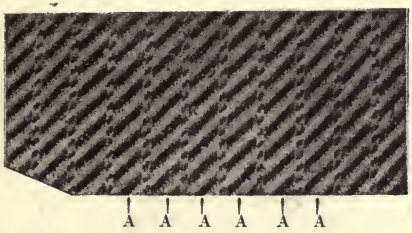


FIG. 122

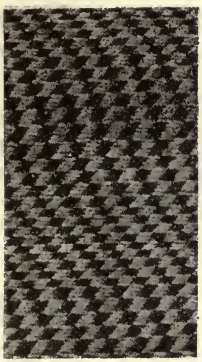


FIG. 123

A corresponding principle of intertexture is practised in the construction of the specimen in Fig. 123, with the weave base inverted, as indicated in Plan B, Fig. 124, and the fabric

picked 1-and-1 instead of being warped in two colours of yarn thus arranged. Now the warp threads are inert as concerns the formation of the pattern details, being covered by the picks of weft. Again the colour scheme is 1-and-1 with the dark and light shades interchanging in groups of 8, 6 and 4 picks, producing the varied interrupted twillings observed in the pattern.

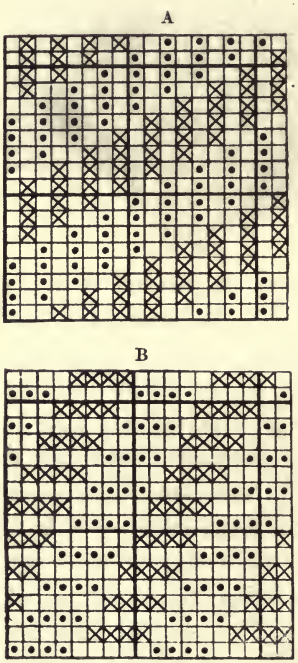


Fig. 124

153. *Design Composition for Weft Scheme.*—To imitate a design woven in one shade of warp and a second shade of weft, as for example Fig. 121, in the weft structure of cloth, the weave plan, Fig. 121A, is transferred on to the alternate picks of the new plan as shown in the sectional design, Fig. 121B. Then the intervening or even picks are, as closely as possible, made to agree with the warp intersections of the picks of the basic plan, but marked as weft interlacings. Examining and comparing Figs. 121A and 121B will render these technicalities plain. The odd picks—in ■'s—of the latter are identical in interlacings with picks 1 to 12 of the former; but the even picks of Fig. 121B are the reverse in interlacings of the picks in Fig. 121A; that is, the 2nd, 4th, 6th, etc., picks of the sectional plan correspond in weft intersections with the warp intersections of picks 1, 2, 3, etc., of the original design. Completing Fig. 121B on this basis and applying it to a cotton warp and woollen weft union (2-fold 30's cotton, 16's reed 2's, 9 skeins weft, and 44 picks per inch) would result, should the odd picks be woven in black and the even picks in grey, in an effect similar to that sketched at B in Fig. 121. If

intended for a piece-dyed cloth, one series of picks would consist of yarn spun from wool fibre (*i.e.*, mungo or shoddy), and the second series of picks of vigogne yarn or an admixture of animal and vegetable material.

154. *Converting Weaves into Warp or Weft Plans.*—On

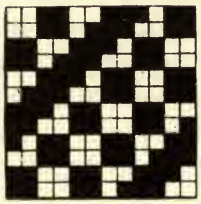


FIG. 125

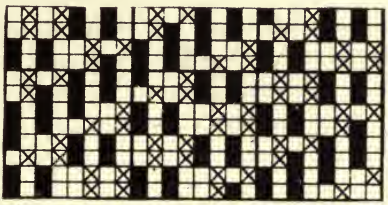


FIG. 125A

the system illustrated and described, many varieties of ordinary weaves may be converted into warp or weft plans. Two examples are supplied in Figs. 125 and 126, 12-shaft

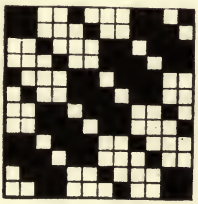


FIG. 126

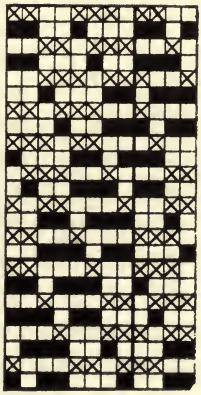


FIG. 126A

twilled makes. Rearranging the former for a worsted warp and cotton weft piece-dye or coloured pattern, the weft floats, of the original weave, are run on to threads 1, 3, 5, etc., of the required design as shown in Fig. 125A, following by marking the warp intersections on the even threads of the modified or extended plan. The same rule is observed

in reconstructing Fig. 126 for a union cloth with the twills formed in weft and concealing the warp yarn; but, as seen in Fig. 126A, the process of opening out is applied to the picks of the plan, Fig. 126, and not to the threads, as in Fig. 125. Within certain limits, checked designs are producible on this principle of loomwork. Thus, Fig. 127 is derived from a 4-and-4 twill cutting at each fifth thread, dividing the basic plan in the warp ends in alternate order, and twilling sections A to the left, and sections B to the right. The design, as arranged, is suitable for a warp-face texture with the picks of weft invisible as in Fig. 124, A and B; but if it should be turned round, and threads changed to picks, it would be equally adapted for a weft-face union in which the warp ends would be concealed. A number of the plans, formed by this method, are usable for either one class of union fabric or the other, more especially if the intersections of warp and weft are equally balanced in the fundamental weaves selected. In transposing the structure of the plans, the loom setting requires to be revised, the warp type necessitating more threads than picks per inch, and the weft type more picks than threads, for the accurate definition of the design elements in the fabric.

155. *Patternwork in Warp or Weft-face Unions—Piece-dyed.* —The range of patternwork is not restricted, in these principles of weave structure, to the use of coloured yarns in either the warp or the weft, but extends to bi-fibred yarn manufactures, and includes the acquirement of textural design as a product of one of the two groups of yarns in the fabric in one or two shades and piece-dyed. It has already been explained how several varieties of ordinary textures are thus dyed and yet distinguished in style and in weave details, but as the latter are the result as in Fig. 121 of two systems of intersection—warp and weft—their expression in the fabric is strictly a work of plan origination. The two orders of interlacing, whether uniformly or differently devised, are equivalent, when suitably combined and arranged, to delineating, in a

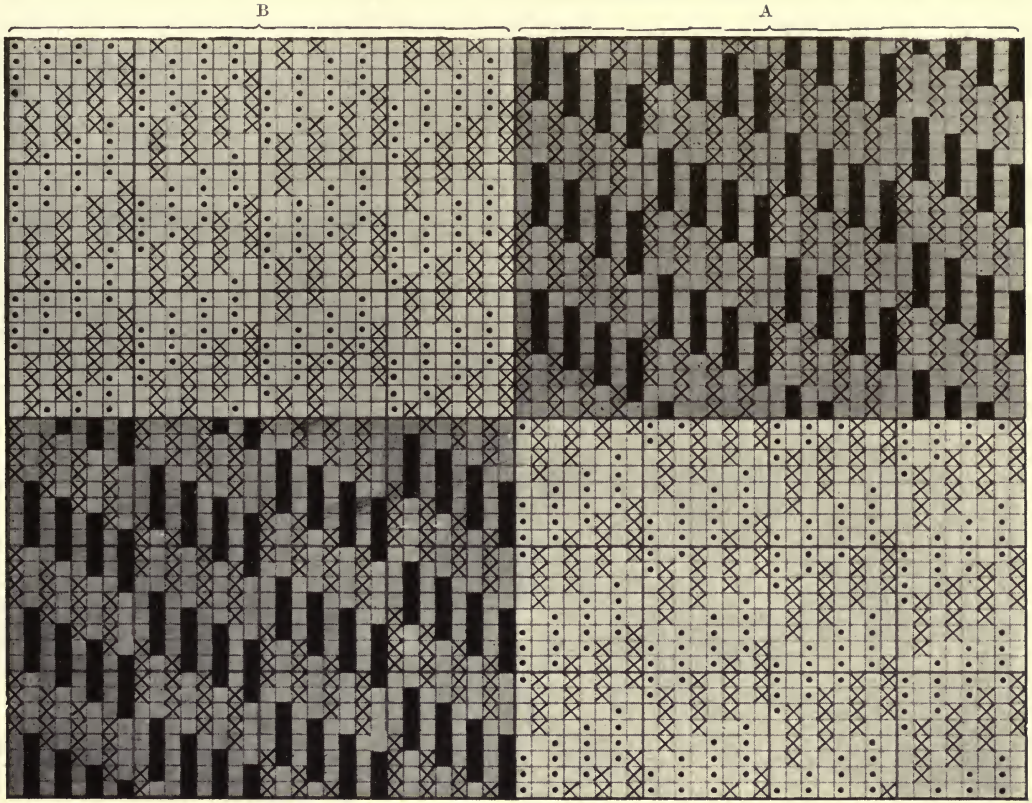


FIG. 127

distinct textural form, either elementary or involved pattern features. Thus, the different effects of twill, mat and fancy crossings, woven in one-shade cloths, are purely the consequence of the contrasts developed by the floats of the warp and weft being placed, in weaving, at right angles to each other. In unions of the class under analysis no such structural differentiations are attainable. Still weave emphasis of a sort is feasible, and a number of the standard makes of cloth may, by applying certain rules of intertexture, be closely imitated, though the weave effect is due chiefly to warp or weft floats, but not to both. Examine, for example, the plan given in Fig. 128, the union crossing for producing a 3-and-3 twill solely in the picks of weft, and also for preventing, in the formation of the twill, the binding threads in the warp from appearing either on the face or the reverse side of the fabric.

Combining intersections of dissimilar measurement, as in Fig. 129, will obviously enable the twilling to be clearly accentuated, and this is one of the factors which admits of structural diversification. But, it should be noted, that, even in the use of varied interlacing elements, the types of pattern and fabric acquired in this way lack, as compared with cloths in which both the warp and weft intersections are assertive features in the origination of the design, a degree of completeness and of detail distinctiveness.

Textural construction and pattern are each obtained by the interchange or "cutting" of the intersections on the odd and even picks (Figs. 128 and 129), or on the odd and even threads (Figs. 132 and 133). Each series of yarns—marked in ■'s and in ⊠'s—appear successively on the face and back of the cloth, developing in such weaves as Figs. 128 to 133, a similar effect on both sides of the piece.

156. *Manufacturing Data—Piece-dyed and Loom-coloured Unions.*—A study and dissection of the subject will be aided by a reference to the weaving particulars applicable to the several plans illustrated. These are as follows—

TABLE XXI

Manufacturing Data—Piece-dyed Loom-coloured Unions

Weaves.	A. Piece-dyed—Solid Shades.		B. Piece-dyed—Two Colour Tones.		C. Loom-Coloured Fabrics.		Reed.	Picks.
	Warp.	Weft.	Warp.	Weft.	Warp.	Weft.		
Fig. 128	2/40's cotton	8 sks. woollen	2-fold 40's cotton	1 pick of (*a*) 8 sks. woollen $^{70W}/_{30C}$ 1 pick of (*b*) 8 sks. woollen $^{50W}/_{50C}$	2-fold 40's cotton	1 pick of 8 sks. Shade 1 1 pick of 8 sks. Shade 2	16's/2's	48
Fig. 129	,,	,,	,, ,,	As above	,,	As above	18's/2's	42 to 44
Fig. 130	,,	,,	,, ,,	1 pick of (*c*) 10 sks. woollen $^{90W}/_{10C}$ 1 pick of (*d*) 10 sks. woollen $^{60W}/_{40C}$	,,	As above, but 10 sks. woollen	19's/2's	52 to 56
Fig. 131	,,	,,	,, ,,	As above	,,	,,	,,	56 to 60
Fig. 132	2/44's worsted	15's cotton	1 end of (*e*) 2-fold 44's bi-fibred worsted $^{85W}/_{15C}$ 1 end of (*f*) 2-fold 44's bi-fibred worsted $^{60W}/_{40C}$	15's cotton	1 end of 2/44's Shade 1 1 end of 2/44's worsted Shade 2	15's cotton	20's/4's	60
Fig. 133	2/56's worsted	18's cotton	As above, but 2/56's yarn	18's cotton	As above, but 2/56's yarn	18's cotton	22's/4's	68
Fig. 134	2/60's worsted	20's cotton	1 end of (*g*) 2-fold 60's bi-fibred worsted $^{90W}/_{10C}$ 1 end of (*h*) 2-fold 60's bi-fibred worsted $^{70W}/_{30C}$	20's cotton	1 end of 2/60's worsted Light shade 1 end of 2/60's worsted Dark shade	20's cotton	24's/4's	62
Fig. 135	2/50's worsted	16's cotton	As Fig. 132, but 2/56's yarn	16's cotton	As above, but 2/50's yarn	16's cotton	20's/5's	70

157. *Three Systems of Construction.*—Three systems of manufacture in the construction of these cloths are here exemplified. In the first system, the weft-face textures are woven in cotton warp and woollen weft, and the warp-face textures in worsted warp and cotton weft, the yarn units in each class of texture being identically tinted in the dyeing of the goods. In the second system, the warp yarn in Figs. 128 to 131 is also cotton with the weft yarn in two qualities as indicated in picks (*a*) and (*b*), and in picks (*c*) and (*d*); while in Figs. 132 to 135 the warp yarns consist of bi-fibred worsted as indicated at (*e*) and (*f*), and at (*g*) and (*h*), with the weft yarn made of cotton fibre. Both these schemes give fabrics suitable for piece-dyeing, but in Scheme A the cotton and the woollen or the cotton and the worsted threads, should be similarly tinted in dyeing for producing a solid shade of colour, whereas in Scheme B the weft yarns (*a*) and (*b*) and (*c*) and (*d*), and the warp yarns (*e*) and (*f*) and (*g*) and (*h*) would, in the dyeing process, be developed in two shades, one of a darker and the other of a lighter tone. It follows that, in Scheme A, the effects in the cloth are entirely a derivative of the weaves employed, producing in Plans 128 and 129 twills of equal and unequal width, in Plan 130 an irregular mat, and in Plan 131 a striped pattern in eight-end twill, $\frac{1}{4}\frac{1}{2}\frac{1}{}$, the striping being due to the interlacings on the odd picks in the design in Section A, being transferred to the even picks in Section B. These pattern types would all be formed in weft, for the intersections are arranged to cover the warp on both sides of the fabric. The warp-face plans would, in Scheme A, yield other types of effect, composed of the warp threads with the shots of weft concealed, namely, in Fig. 132 a double twill, in Fig. 133 a small diagonal, in Fig. 134 a lozenge spot, and in Fig. 135 a waved or serpentine pattern.

While these textural variations are the consequence of weave principles in Scheme A, in Schemes B and C the design elements are a product of weave in association with colour units,

obtained in the former—A—by the qualities of yarns combined in the warping end-and-end, and in the wefting pick-and-pick, taking different shade tones in piece-dyeing ; and in the latter—B and C—by the employment in the shuttling of Figs. 128 to 131, and in the warping of Figs. 132 to 135, of two colours of yarns.

158. *Methods of Emphasizing Weave Details.*—There are three important methods of emphasizing the weave intersections in union fabrics. They consist, first, in selecting two counts of yarn—*weft* in Figs. 128, 129, 130 and 131, and *warp* in Figs. 132, 133, 134 and 135 ; second in using two qualities of warp or weft ; and, third, in combining yarns of right- and left-hand twine for the effects in the plans woven in the odd and even picks or threads, as the case may be, These technicalities need to be made clear. Figs. 128 to 131, if manufactured according to the data supplied, make a class of heavy union suiting or overcoating should they be wide set in the loom and well felted. Apparently, as in these examples the 1st, 3rd, 5th, etc., picks form one variety of effect, and the even picks a second variety of detail, two counts, qualities, or twists of yarn may be applied, that is, one for each set or group of weave types in the plans. Assuming that a woollen weft—similar to A, Fig. 136—were used in the former, and a crossbred weft—similar to B′, Fig. 136—were used in the latter, the two species of detail, of which each weave consists, would be rendered distinctive in character in the cloth. Corresponding results, as regards the definition of the two classes of effects in the plans, are producible by applying a thicker yarn, say, 6 yds. per dram, to the odd picks in Figs. 128 to 131, and a smaller yarn—10 or 12 yds. per dram—to the even picks. But in this alteration the uniform dimensions of the effects, as represented in the weaves, would suffer, those in the lower counts of weft becoming fuller and more pronounced than those woven in the finer yarn counts.

159. *Yarn "Twine" and Union Twill Movement.*—By the

third method, C, Table XXI, of attaining such textural differentiations, yarns of a like quality but in two shades- *Wefts* 1 and 2 in Figs. 128, 129 and 130, and dark and light *Warp* threads in Figs. 132 to 135—are combined. Pattern characteristics are, in these instances, a result of employing contrasting yarn colours, one coloured series of yarns being applied to the odd and the other to the even *picks* in the former examples, and to the odd and the even *threads* in the latter. An important modification of this principle consists in selecting yarns of the same quality and also of a similar shade but of reverse twine, and warping or wefting them one-and-one, that is, in agreement with the design structures. This practice of production may be explained by considering Specimens A and B, Fig. 136, the fibres of which are twisted in spinning to the left and the right respectively. When two weft or two warp yarns, classified one-and-one, are thus admixed in weaves constructed on the plan of Figs. 128 and 132, they develop different surface features in the cloth. Twill and twine direction being in conformity in one instance and in disagreement in the other, they are responsible for each series of interlacings, though identical in kind and order, having a distinct tone or quality in the dyed and finished fabric. To apply to the picks—Figs. 128 and 129—marked in ■'s, a weft yarn A, Fig. 136, and to the picks, marked in ⊠'s, a weft yarn of equal counts but of the twine seen in B, would cause the twills in black in the plan to be subdued or flattened in tone as compared with those in crosses which would appear more clearly defined. In a like manner, applying to the odd threads—Figs. 132 and 133—a warp yarn corresponding in twine to A, and to the even threads a warp yarn of equivalent twist to B, would impart distinctiveness to the former and indefiniteness to the latter. Prior to the dyeing and finishing treatment these differences are not specially marked. Effects, however, of this nature, and originated by the relation of the yarn twist to the line and order of the interlacings in the weave, become emphasised with colour application, and also

with the clearness of the woven surface acquired in the processes of piece cleansing, dressing or cutting, and pressing.

160. *Effect of "Twine" Direction in the Yarn in Union Textures.*—Yarn construction is, in these classes of cloth-dyed or loom-coloured unions, a salient feature. It is efficient in modifying both the quality of the tinting and the delineation of the design plan. The simple process of twine direction in making the thread presents the fibres in different serial order on the face of the fabric, so that with the yarns distributed by the weave intersections, regular sequence groupings of the threads of right- and left-hand twist occur alternately, varying the technical characteristics obtained in the woven structure. Thus, employing a weave of the scheme illustrated in Fig. 131, and wefting one pick of 10 skeins "open-band" and one pick of 10 skeins "cross-band," forms section A with the twine in the yarn the reverse of the twill, and section B with the twine in a line with the weave or twilled movement. In dyeing, and especially in the work of finishing, the twilled elements in A assume, as a consequence, a decisive, and in B an indefinite, line structure. From which it will be understood that, by arranging weave types of this category, *i.e.*, twills which, in the design scheme, traverse the piece in the same direction, and bring alternate picks on to the face and back of the cloth, several forms of pattern are producible in piece-dye cotton and wool fabrics, in which one moiety of the yarns—woollen or worsted—is employed in developing textural effects; and the second moiety of yarns—spun from cotton or vegetable fibre—in binding the two series of threads into a compact, woven production. What might be judged, on

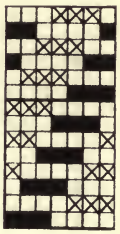


FIG. 128

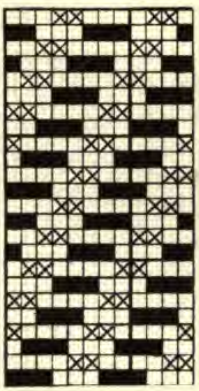


FIG. 129

a casual examination, as a technical detail in the construction of these fabrics, links dyeing efficiency with manufacturing success. Weave definition, and intersection contrasts, are rendered possible in *warp* or *weft*, and shade tones obtainable. which would otherwise be absent from the dyed texture if the filaments in the yarns were not, as explained, presented in two directions on the surface of the fabric, and in the formation of the respective sections of the pattern.

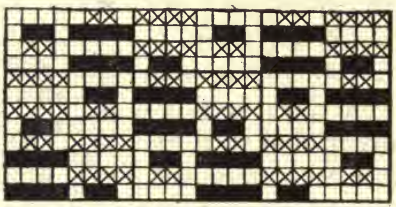


FIG. 130

Modifying the design plan —Fig. 137—enables diversity of pattern style to be acquired in two simple twills, which in combination, interchange the picks of weft from the upper to the lower side of the cloth and *vice versâ*, for producing the clear and subdued weave features. In this example the twilled sections in grey, if shuttled one pick of right-hand, and one pick of left-hand twine yarn, would be well accentuated, but the twilled sections in white would be less pronounced in character. As weaves of this description are combinable on different bases, the standard forms of pattern made in piece-dye cloths, with the warp and weft threads interlacing successively on both sides of the fabric, are weavable, in this system of union intertexture, with only one of the two yarn ingredients in the manufactured fabric visible.

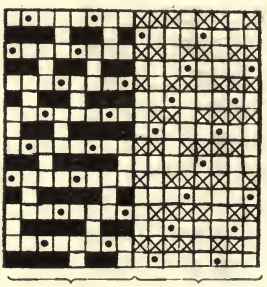


FIG. 131

161. *Tone Differentiation in Dyeing due to Yarn Twine and Structure.*—The three technicalities considered—yarn composition and quality, twist formation in spinning, and the assortment of yarn structures—as fundamental factors in the development of pattern in union cloths, manufactured

for piece dyeing, increase in interest and suggestiveness when more fully studied and experimentally investigated. "Twine" direction in the surface yarn of the texture, as shown, is a primary element, being capable of differentiating the shade

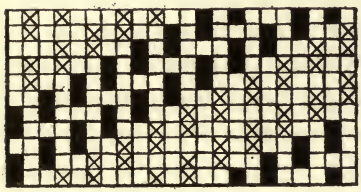


FIG. 132

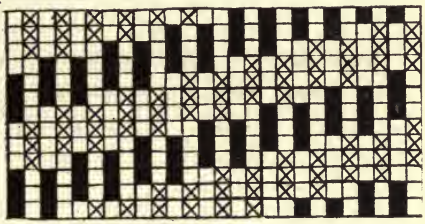


FIG. 133

tone of one twill from the shade tone of an adjacent twill (sections A and B, Fig. 131), or the shade of the ground and that of the design (white and grey sections, Fig. 137), though both are woven in the same counts and quality of yarn. Strictly,

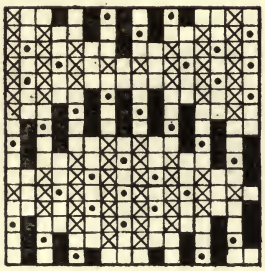


FIG. 134

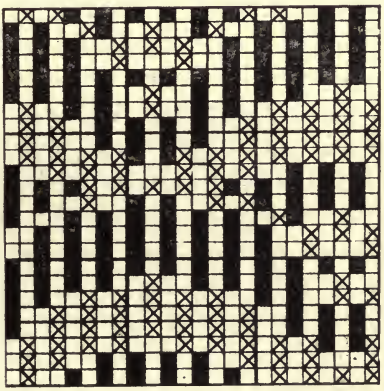


FIG. 135

in such manufactures, colour contrast does not exist, and weave contrast may also be absent, yet, as a result of the yarn twisted to the right possessing a distinct fibrous appearance and effect from the yarn twisted to the left in the relations indicated, pattern characteristics are clearly definable in the fabric. Hence, in the compound striped plan (Fig. 131),

with the twills in A corresponding to the twills in B, each is differently emphasized; and, similarly, in the small figured combination (Fig. 137), the style details are made evident in the texture by the yarn "twist" giving, in the dyed piece, a fuller and deeper tone to the ground than the reverse yarn "twist" is competent of imparting to the design characteristics.

162. *Experimental Schemes.*—Basing experiments on these structural properties of woollen or worsted yarns, several varieties of wrap, cloaking, and rug fabrics are weavable in the *weft* scheme, and of dress and costume textures in the *warp* scheme of intertexture, with both groups of manufactures equally adapted for piece-dyeing. Considering the first of these textural types, the fabrics should be dyed in warm, intense colours, avoiding dark and sombre shades as detracting from the effects yielded by the two varieties of twine in the yarns used. The plans should be constructed on the principle of Fig. 137, and range, in the weaves combined, from twills of 45 to 60 or 70 degrees in the cloth. The weave units are combinable in (1) herring-bone stripes and in regular and irregular checkings; and (2) in the origination of geometrical patterns draftable on to a limited number of threads, facilitating their production in shaft mountings.

Fig. 138 is an example of this class, with the weave marked in ⊠'s in Fig. 137 for ground, that in ■'s for the star features in medium grey, and a weave arranged 2 picks face and 2 picks backing for the diamond spots in light grey. When thus developed, it may be produced in a 32-shaft loom, but, with a suitable elimination of detail, a similar form of design could be made in 24 heddles. It is typical of a scheme of manufacture—cotton warp and mungo, shoddy, woollen or vigogne weft—by which pattern qualities, neatly delineated in the piece, are obtainable in single-process dyeing. Discarding colour variation, and depending upon differences in yarn twine by shuttling one pick of "crossband" and one pick of "open band" weft, the twilled features in the figuring, and in the ground, would be distinguishable from each other.

In the ground—Fig. 138—they would take, comparatively, a bright tone, in the dark sections a dull tone, and in the light sections—the two sorts of weft yarn intermixed—an intermediate tone of colour.

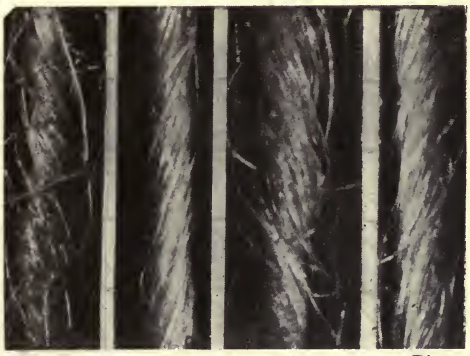


FIG. 136

Piece scouring, milling, and raising to comb out and brush up the surface filament for clear cutting, further define the formation and features of the pattern. Taking, for instance, the fabric to be dyed a bright, warm brown, the parts of the design woven in the left-hand twist yarn—A, Fig. 136—would be more distinctly outlined and developed than the parts of the design woven in the right-hand twist yarn—B′,

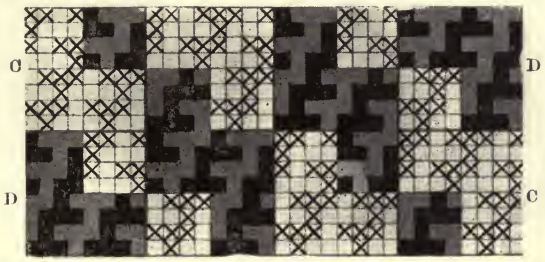


FIG. 137

Fig. 136—because, as explained, in one case the twine in the weft would be the reverse of the line of the twill in the weave, and, in the second case, the yarn twine and the twill movement would be in coincidence.

163. *Curtailment of Weave Diversification.*—On the weft principle of manufacture, weave diversification is not, as a rule, to be practised. The interchange of the picks in the

two plans employed, as seen in Fig. 137, is the technicality which ensures the location in the cloth, as required, of the two kinds of yarn utilized. Still, experiments are feasible

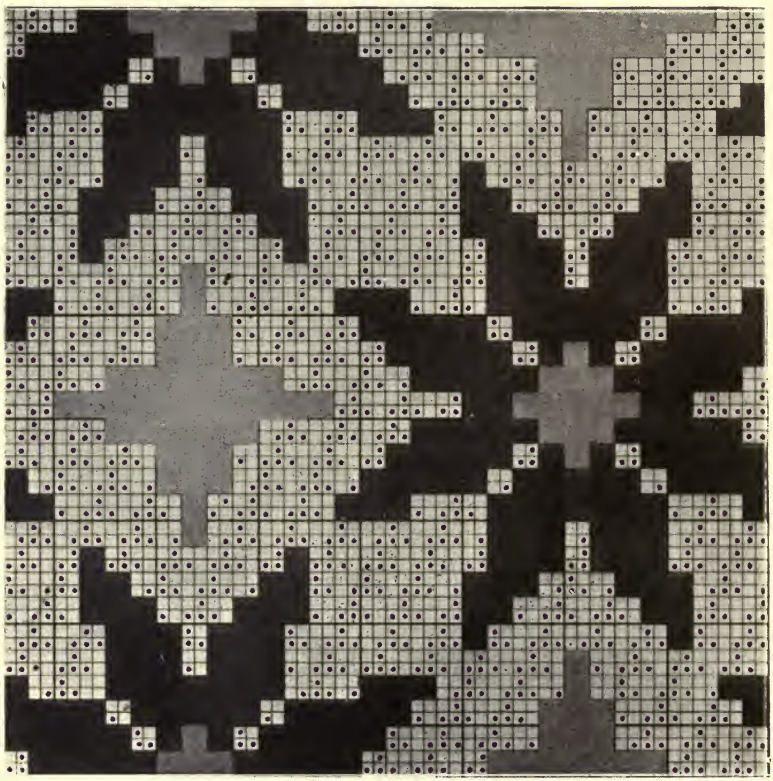


Fig. 138

in the application of weaves of different systems of intersection, as, for example, twills A and B, Fig. 131, with twills C and D, Fig. 137. Additional textural contrasts are thus acquired, and the facilities for pattern contrivance and origination are thereby amplified; but it is essential that the weaves selected and combined should perfectly conceal the cotton warp, and give a satisfactory fabric as to firmness, and as to wearing strength and durability.

164. *Utility of Yarn Quality and Structure in Design Delineation.*—Pattern delineation is also attainable, in heavy makes of cloth, well-milled and raised, providing two qualities or two varieties of yarn, in addition to yarns of contrary twine, are employed as weft. Combining a shoddy yarn, resembling a Cheviot thread, with a Crossbred worsted yarn of equivalent

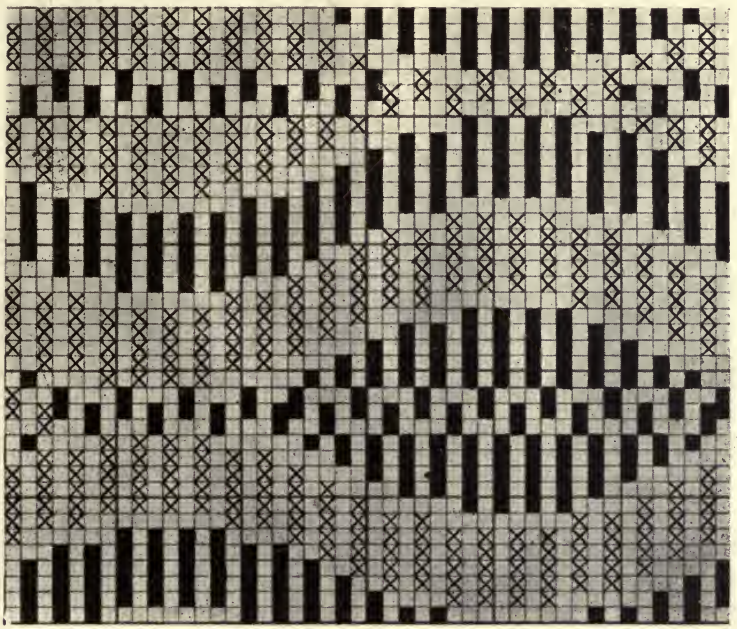


FIG. 139

counts, results in the respective surfaces of the fabric in which they occur being developed with dissimilar fibrous characteristics. This will be understood on comparing the Cheviot and Crossbred specimens A and B′, Fig. 136, as they appear under the microscope, one type of thread marked with intermingled and extraneous straggling fibre, and the other with the filament more symmetrically disposed, and the thread more uniform and compact in structure. Now, it will be obvious that, if Fig. 138 were woven in yarns constructed of

materials such as shoddy on the woollen system, and of English crossbred wool on the worsted system, giving yarns of a like formation to A and B′, Fig. 136, by applying the first quality of thread to the ground sections, the second quality to the portions in grey, and the two yarns intermingled by the weave to the tinted grey portions of the design, each textural surface would be sufficiently distinct as to render the pattern style traceable, though the colouring of each material and yarn, as ensues from piece-dyeing, would be identical.

165. *Raising Action and Design Quality.*—Raising does not obliterate the integral parts of the design in such a combination for two technical reasons: first, the materials and yarn structures in the process retain their inherent properties; and, second, the points of the teazles or card wire exert a different relative action on the groups of fibres twisted to the left in the Cheviot, and on the fibres evenly aligned with each other and if twisted to the right in Crossbred thread. Selecting mungo—or a short-stapled material—for the carded yarn, has the effect of emphasizing the surface features due to each yarn in the woven and in the finished manufacture. A yarn of this filament consistency—fine wool or mungo—produces a soft, full tone of texture in strong contrast with the bright, clear tone of texture, formed in the worsted thread. By this system of looming, in either mungo or shoddy yarns inter-weaving with worsted yarns of the same diameter, the patterns possess, after dyeing and finishing, an embossed appearance and character.

Fig. 140

The raised-face finish is adapted to cloths of the rug

description, but the clear finish to medium and light fabrics, in which the smaller yarns applied are usually comparatively firm spun as weft, with a view of adding to the tensile quality of the woven product. This degree of twine in the yarn is, in the finishing routine, made effective in delineating the twilled lines when traversing the piece contrawise to the direction of the twine in the threads in which they are produced; and, conversely, in subduing such lines when moving in agreement with the direction of the filaments in the twisting of the yarns employed.

Fig. 141

166. *Warp Scheme of Fabrication.* —The warp scheme of intertexture —two qualities of warp and one quality of weft yarn—offers some latitude in design origination. Fine spun yarns, 2-fold in structure (see the Weaving Data for Figs. 132 to 135, Table XXI) render contrasts, resulting from weave types, sufficiently pronounced to provide for several groups of pattern elements, each of a distinctive textural formation, being blended together in the same style of design. Limiting the materials used to yarns consisting of wool or animal fibre in the warp, and of cotton or plant fibre in the weft, so that dyeing—Scheme A, Table XXI—may be performed in one process, there are salient advantages, in weave arrangement and combination by this method of fabrication, as contrasted with the pattern schemes feasible in the weft-surfaced cloths analysed.

Primarily the subject is illustrated in Figs. 134, 135 and 139, formed of warp-cord plans, diversified in the dimensions of the interlacings, and in the design types they produce. The lozenge form of effect—Fig. 134, marks = warp face—is illustrative of the plan of stitching the warp ends frequently with the weft when not used in the face of fabric, which causes the underside of the texture to have a plain woven appearance. In the instance of the sinuous waved pattern, Fig. 135, and of the figured cord pattern, Fig. 139, such stitching is not practised, so that, in design features, these fabrics are reversible in construction. The alternate thread lines, marked in ■'s and in ☒'s in the examples, are woven in ordinary and in reverse twine, hence, in the tinting of the piece, each series of effects assumes a different shade tone, and this results in their being clearly observed and distinguishable one from the other.

Such weave and thread formations, enhanced in their textural character and design value by finishing practice, indicate the nature of the technicalities for experimental study in the origination of styles, suitable for piece-dyeing, and plain or elaborated in figuring, and elementary or involved in plan of construction. Specimens of the first variety are sketched in Figs. 140 and 141. The problem is one of producing both ground and pattern in contrasting weave units, acquiring detail textural types in the *warp* yarns by covering the *weft* intersections, and by combining worsted and cotton (or equivalent fibrous substitutes), and enabling each feature in the design scheme to be successfully developed in a piece process of tinting.

167. *Ornamentative Style Origination.*—Two fundamental methods of manufacture may be examined. First, styles in which the pattern types are distributed over the surface of the cloth, with intervals between the spottings or detached figures,—Sketch 140—are adapted for construction in weave units differing in intersection fineness, such as have a more open plan for the groundwork than for the figuring. Applying this

principle to the production of Fig. 140, the warp twill in Fig. 142 is suitable for the ground sections and the 2-and-2 warp

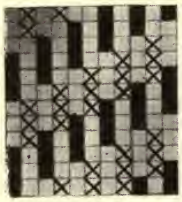


FIG. 142

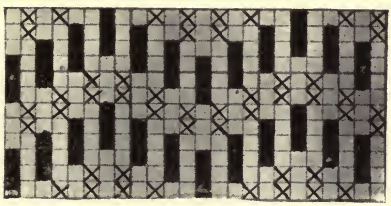


FIG. 143

cord for the development of the figured details. Both crossings would conceal the cotton weft, and both would be

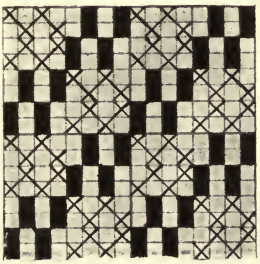


FIG. 144

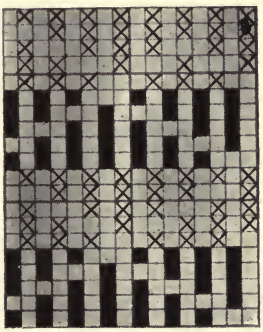


FIG. 145

smartly defined in the texture by the two "twists" of thread used in the warp end-and-end; and, in addition, two tones

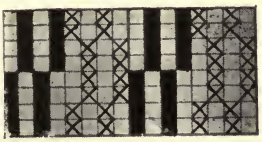


FIG. 146

FIG. 147

of colour would result in the dyeing of the goods. Other weave assortments applicable would be the checked cord,

Fig. 144, for ground and the 3-and-3 cord for figuring, or the diamond make, Fig. 145, for the former and the waved twill, Fig. 143, for the latter.

Second, when the pattern devices and the groundwork are each being continuously formed, in the weaving of the fabric as in Fig. 141, the weave schemes should, as regards intersections, be closely related, otherwise, in dyeing, the pieces have a disposition to crease or crimple. One practice, in securing a faint outlining of the design, is to employ the same twilled weave in all parts of the fabric, but moving to the right and to the left, as in A and B, Fig. 147. Thus, using plan A for the dark parts of Fig. 141 and plan B for the light parts would, with the warp made of one kind of yarn, cause the ground portions to be produced in smartly-defined twilled lines, but the figured portions in lesser distinct textural effects, as in these the direction of the twill, and of the twine in the warp yarn, would correspond.

Fig. 148

The application of this class of weave implies close warp setting, to accentuate the contrasts yielded by the different movements of the twills in the ground and figured surface of the texture. The weaves—Fig. 147—being two-ply in the warp, and the reverse in warp interlacings of each other, result in the distinctiveness of pattern construction, and also in shade tone, following the process of dyeing. If, however, more pronounced textural contrasts are desirable, 3-and-1 twill and 5-end sateen weaves, similarly arranged to A and B,

may be applied ; or, if the production of such styles is needed in single weave elements, then plans of the structure illustrated in Figs. 142, 144 and 146 are appropriate for ground purposes,

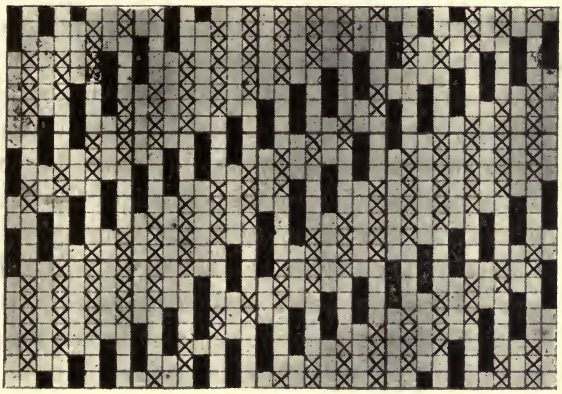


FIG. 149

and weaves of the fine twilled cord variety—*e.g.*, the Venetian, on 5 or 7 shafts—for the formation of the decorative details.

168.—*Weave Elements and Pattern Values.*—In patterns consisting of several species of woven effect, the delineation of each feature is obviously acquired by changing the weave elements. The combination of two or three qualities of yarn (see Figs. 140, 141 and 148) with a special and distinctive ground texture, cannot be satisfactorily emphasized in piece-dyed union fabrics of this order, without resorting to the employment of particular weave units for the ground and each figured section in the designs. Yet it is necessary that the effects combined shall be formed in the warp yarns, the weft picks be invisible in the cloth, and that the direction of the twine in the alternate threads—unless the weaves are reversed in twill, as in A and B, Fig. 147—shall impart two tones of tinting and two qualities of textural surface. Generally, designs fairly profuse in

FIG. 149A

form detail, as in Fig. 148, involve the use of a simple plan of intertexture for the ground, such as the crossings in Figs. 142, 143 and 146. Having determined this, the weaves for the dark and light portions of the figuring in the example would be selected. Here, if the compactness of form outline observed in the sketch is to be retained, it is desirable that the " makes " for these sections should be derived from the same intersection principle, say 3-and-3 and 2-and-2 warp cords respectively. Three weave elements would thus be combined, which would give character to the ground of the fabric, and also to the two varieties of detail in the figuring, and at the same time suitably accentuate the colour tints, developed by dyeing yarns of reverse twist and appearing in successive order in the twills in the ground, and also in the broader and smaller reps of the cord weaves of the pattern details.

169. *Bi-fibred and Single-Quality Yarn Schemes.*—Schemes B and C for looming practice relative to these manufactures, and specified in Table XXI for both the *weft* and *warp* systems of fabric construction, do not require, in consideration of the full analysis made of the technicalities comprised in the application of Scheme A in Paragraph 169, any lengthy or detailed examination. It will be understood that, with the contrasts in colouring which these systems of intertexture afford, all the textural styles described are obtainable in different degrees of clearness. For illustration, in selecting the bi-fibred warping, Fig. 132, Table XXI, for the weaving of Fig. 149, and wool-dyeing the piece a dark shade, develops the pattern features in stripings A, Fig. 149A. Turning the plan round, and wefting pick-and-pick, as in Fig. 131, Table XXI, and also dyeing the cloth a dark colour, would give a similar type of textural pattern but formed in the weft and not in the warp yarn. In these, and all corresponding varieties of union fabrics, the cotton yarn should be stained or dyed a neutral shade to link it in colour tone with the shade acquired in the dyeing of the piece lengths. This is also the practice in the production of the manufactures in accordance with

Scheme C, in which coloured yarns are employed in the warp or weft having regard to the description of pattern to be acquired in the loom and in the finished cloth. The weaving technology and design principles, defined and dissected, are common to the three systems of looming indicated in Table XXI, but the formulae of manufacture are necessarily varied with the system of fabrication applied.

CHAPTER IX

TEXTURES LIGHT IN CONSTRUCTION

170.—Woven Types of Thin Union Fabrics. 171.—Lustre Dress Fabrics. 172.—Material Characteristics. 173.—" Lustre " and Yarn Contrasts. 174.—Textural Sheen. 175.—Standardized Lustre Manufactures. 176.—Glacés, Sicilians, Plain Orleans and Italians. 177.—Russell Cords, Poplins, Repps, and Crêpes. 178.—Designing Principles in Lustres. 179.—Pattern as a Resultant of Weave Elements. 180.—Alpaca Coatings. 181.—Figured Lustres. 182.—Worsted Warp and Silk Weft Structures. 183.—Worsted and Cotton Warp with Silk Weft for Pattern Production. 184.—Essentiality of Warping and Wefting Orders. 185.—Gimped-Yarn Ground Textures. 186.—Two-ply Warp and Weft Thin Cloths. 187.—Worsted and Silk-Warp Schemes of Intertexture. 188.—Variations in Ground Characteristics. 189.—Cotton and Artificial Silk Example. 190.—Bordered Pattern in Worsted and Silk-Warp Principle. 191.—Acquirement of Decorative Styles. 192.—Silk Warp and Worsted Weft. 193.—Warp Matelassé Type. 194.—Silk or Cotton and Worsted Yarns in Warp and Weft. 195.—Weave Units and Colour Arrangement. 196.—Compound Light or Thin Fabrics formed in Open- and Fine-set Structures. 197.—Analysis of Looming Practice. 198.—Surface Features. 199.—Net or Lace Grounds. 200.—Crepons. 201.—Characteristic Qualities of Surface Waviness in Fabrics. 202.—Compound Weft-Weave Crepons. 203.—Modification of Weaving Plan. 204.—Double-Weave Undulated Textures. 205.—Technique in Crepon Manufacture. 206.—Leno and Gauze Structures. 207.—Combinations of Lappet and Gauze. 208.—Microscopic Study of Gauze and Lappet Specimens.

170. *Woven Types of Thin Union Fabrics.*—In the manufacture of dress, costume, blouse, and also of thin decorative textures, the employment of two varieties of yarn, one for warp and the other for weft, is a common practice. It forms a system of loomwork which admits of a wide range of design and colour treatment, as well as of some latitude in textural construction, and in methods of fabric finishing.

The pronounced distinction between the yarn structures combined, is an effective source of diversified fabrication, such as results from the interlacing of threads spun of a

lustrous and of a non-lustrous material, and of threads differing in counts, twist and fold.

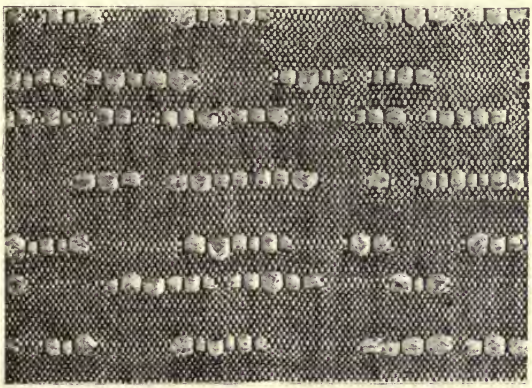


FIG. 150

Cotton is largely used in the warp but worsted and linen are also freely applied in this manner, with mohair, alpaca, silk

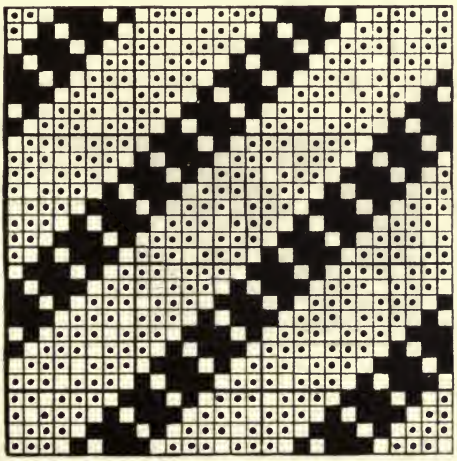


FIG. 151

and artificial silk for weft. The assortment of yarn units, and the methods of their utilization are, in a sense, only

restricted by the schemes of manufacture, which, in practice, have proved economical and efficient; and which have,

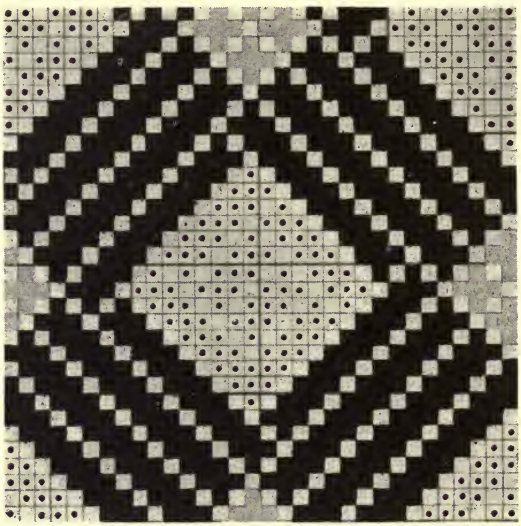


FIG. 151A

therefore, become standardized, though subjective to modification by original study and research.

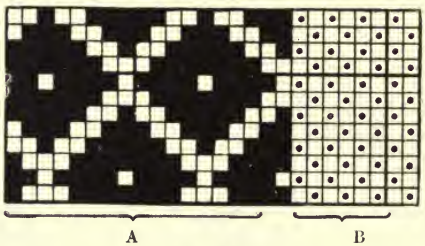


FIG. 152

The following light-made union productions include a number of the typical woven structures, and the yarn combinations applicable thereto:

TABLE XXII

WOVEN TYPES OF THIN OR LIGHT UNION TEXTURES

(1) Lustres, Plain and Figured.—Cotton warp and lustre worsted, mohair or alpaca weft.
(2) Alpaca Linings, Twills, Diagonals and Coatings.—Cotton warp and alpaca weft.
(3) Dress Fabrics, Plain, Twilled, and Figured.—Cotton warp and Silk weft.
(4) Small-figured Effects.—Worsted warp and silk weft,
(5) Linen and Silk Unions.—Linen warp and silk weft.
(6) Lenos and Gauzes, Plain and Figured.—Cotton warp, worsted, mohair or silk weft.
(7) Lappet Fabrics.—(*a*) Cotton-yarn ground, with silk or worsted lappet thread; (*b*) Linen-yarn ground, with cotton, worsted or silk lappet thread.
(8) Compound Gauze and Lappet Structures.—Yarn units as in (6) and (7).
(9) Textures with a Crimped, Waved or Crepon Surface.—Cotton and silk, worsted and silk, etc.
(10) Fabrics Composed of Fine and Open Woven Structures.—Cotton and worsted, linen and cotton, silk and cotton, etc.
(11) Admixed Warp and Weft Manufactures.—Colour, weave, and figured patterns in various yarn types and qualities.
(12) Standard makes of Simple Fabrics, including cords, poplins, repps, glacés, plain Orleans, Baratheas, crêpes, Sicilians, etc.

171. *Lustre Dress Fabrics.*—Lustre manufactures form a prominent section of the dress trade, and originally resulted from the utilization of the alpaca staple. They comprise an extensive and important variety of thin or light union textures, in which the warp yarn is cotton, and the weft yarn alpaca, mohair, or lustre worsted. In the ordinary grade of figured "lustres," the ground of the fabric is plain woven, with the decorative elements developed in *weft* twills, sateens, and similar makes, which float the shuttling yarn freely on the surface of the piece. Intermediate and shaded or irregular effects, combining warp and weft intersections equally, are not found satisfactory, for they either emphasize the cotton yarns too greatly, or they too frequently interrupt and impair the delineation of the design characteristics produced in the weft and lustre yarn.

The term "lustre" is significant of the kind of loom manufacture intended, a fabric or woven "stuff" having the shuttling yarn flushed on the face in the development of the ornamentative features of the style, and one in which this thread

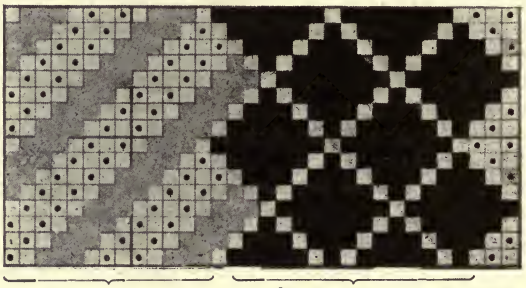


FIG. 152A

imparts brightness of tone. The textural construction, and the design scheme, render this practicable, while the natural properties of the animal fibre selected, associated with the

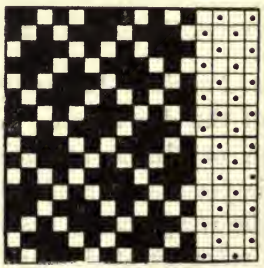


FIG. 152B

system of yarn preparation and spinning, yield the second quality, that of surface sheen and tinted clearness.

172. *Material Characteristics.*—Dealing firstly with the latter condition—alpaca, mohair, and lustre wool, closely resemble each other in physical and in chemical analysis, and also in spinning technicalities. Structurally, the fibres differ in degree and also in fineness and flexibility, alpaca being the superior, in these features, to mohair, and mohair to lustre

wool. Each class of fibre possesses a silky brightness, arising partially from its smooth exterior and straight disposition in the staple; and partially from the nature of its finely-serrated circumference, which is notably even and equalized in the size and order of the scale-like elements of which the outer part of the fibre consists. The marginal scales are perceptibly flatter and closer one to the other, accompanied by diminished individual definition, in alpaca than in mohair or wool, but in each they are well developed and symmetrically grouped from the root to the tip of the filament.

FIG. 153

Considering, secondly, the practice of yarn construction, it is precisely designed and adapted for exhibiting, in the spun thread, the full natural quality of lustre in the raw material used. By gill-box preparation, the staples are uniformly aligned, levelled, and attenuated to their normal length; in combing, the fibres are separately straightened and collectively arranged in parallel relation; and in the drawing operations, by repeated doublings and drafting, the slivers are formed into a perfectly smooth, even, and yet open

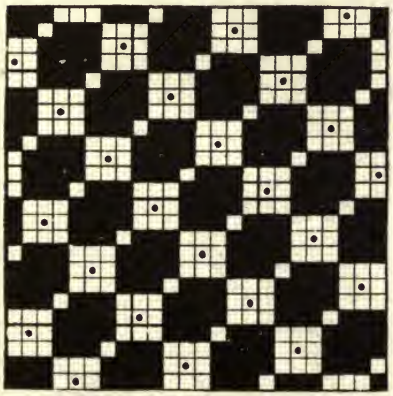


FIG. 154

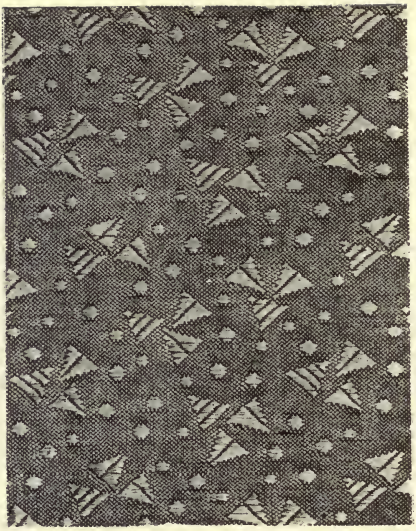


FIG. 155

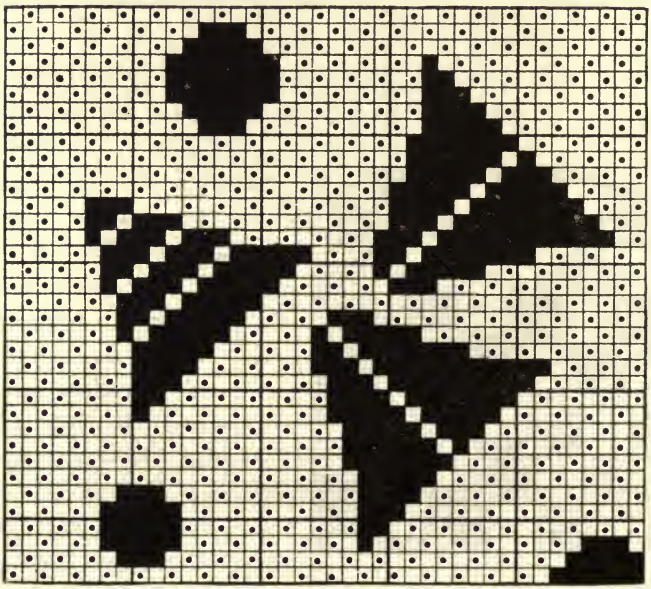


FIG. 155A

Sectional Plan for Fig. 155

roving structure. If follows that the filaments do not so much intersect or cross each other irregularly as lay in a common line in the length of the yarn. The helical and spiral

Fig. 156

fibre movement, accruing in the twisting process, binds fibre with fibre and results in a compact, tensile thread. Filament cohesion in the yarn is helped by the external formation of the fibres, for, in the spinning work, their serrated

surfaces link or dovetail one with the other, and thereby add to the unity and firmness of the resultant yarn.

173. "*Lustre*" *and Yarn Contrasts.*—Other favourable factors to the acquirement of lustre in these manufactures

FIG. 156A

Sectional Design for Fig. 156

are—the contrasts obtained between the fibrous materials, and between the consistency and character of the cotton yarn in the warp and of the animal-fibre yarn in the weft. The staple of one is fine, short, and non-lustrous, and the staple of the other, long, diffusive, flexible, and bright. The cotton yarn is firm spun, frequently two-fold, and comparatively unyielding,

whereas the weft is loosely spun, single, and of a lesser filament density. The spun qualities of the latter induce the fibres of which it is composed, to fill in the interstices betwixt the cotton threads, and to effectively cover from sight all such warp-yarn units in the parts of the texture in which the weft is floated in compact order on to the face, as in the production of the pattern elements.

Textural firmness is derived mainly from the warp, and textural quality mainly from the weft, yarn. The softness and lustre of the finished piece depends, in a primary sense, on the fineness of the staple of the mohair or alpaca. In reducing this, that is, in using a coarser grade of material, though the counts of the yarn may not be varied, the intrinsic as well as the commercial value of the manufactured product is deteriorated.*

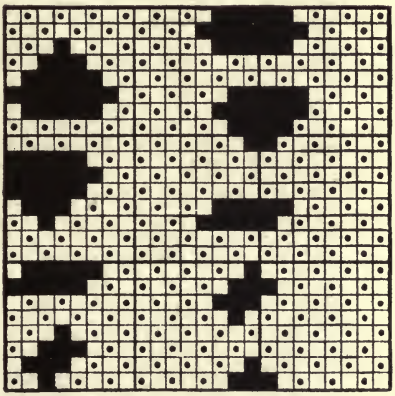


FIG. 157A

174. *Textural Sheen.*—The sheen or bright surface, which mohair, alpaca and lustre worsted impart to the fabric, may be further explained by referring to the fancy Borets specimen reproduced in Fig. 150. The tinted warp yarn is 2-fold 60's cotton, and the white weft 24's lustre. Three varieties of textural contrast result—first, between the coloured warp and the uncoloured weft; second, between the soft-spun worsted and closely-twisted cotton yarns; and, third, between the dull tone of the cotton fibre as compared with the bright tone of the Leicester or Lincoln wool employed in the preparation of the worsted. The flake or blotched effects, caused by floating the lustre picks over 3, 5 or 7 successive threads of warp, accentuate these contrasts. Such picks appear to

* See Paragraph 323 in *Woollen and Worsted.*

flush loosely on the face of the texture, due to the diffusive properties of the material, the filaments of these yarns spreading out laterally in those parts of the fabric where they are not bound by interlacing alternately, as in the ground sections, with the cotton warp ends. In a special degree the bright tone of figured lustres, and of certain types of weft-figured matelassés, arises from the "lofty" quality of the weft or

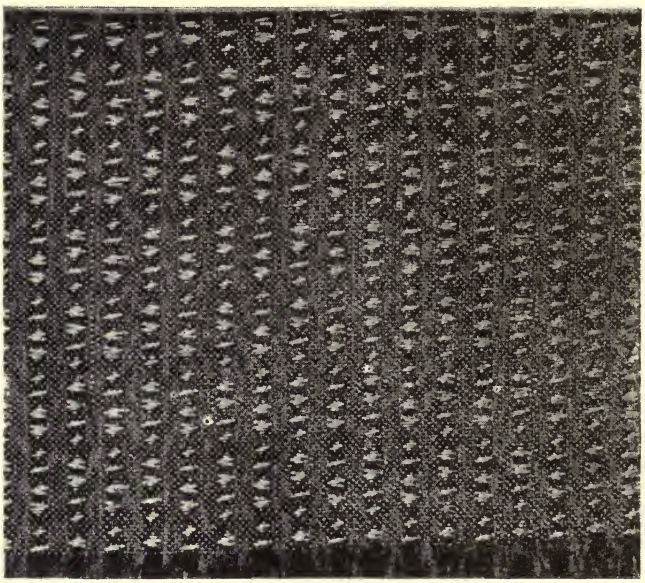


Fig. 157

pattern-forming yarn, but it is enhanced by the method of weaving as shown, and likewise by the finishing practice. The mechanical extension of the pieces in lengths and equalizing of the surface of the fabric which ensues in finishing, brings the lustre-material yarn into greater prominence, and, at the same time, detracts from the distinctness, in the texture, of the cotton threads. All free and loose fibre, or hairy filament, is removed from the goods in the singeing and cutting routine, which has the effect of exhibiting the even and bright formation

of the shots of weft. In the hot-pressing process, through which the pieces pass, the surface sheen or gloss is still further developed, and acquires a permanent quality, or one which is only slightly affected by atmopsheric conditions and friction in the wear of the fabric.

175. *Standardized Lustre Manufactures.*—A branch of industry so fully organized as the dress trade, admits of standardized practice. Alpacas, mohairs, lustres, glacés, Sicilians,

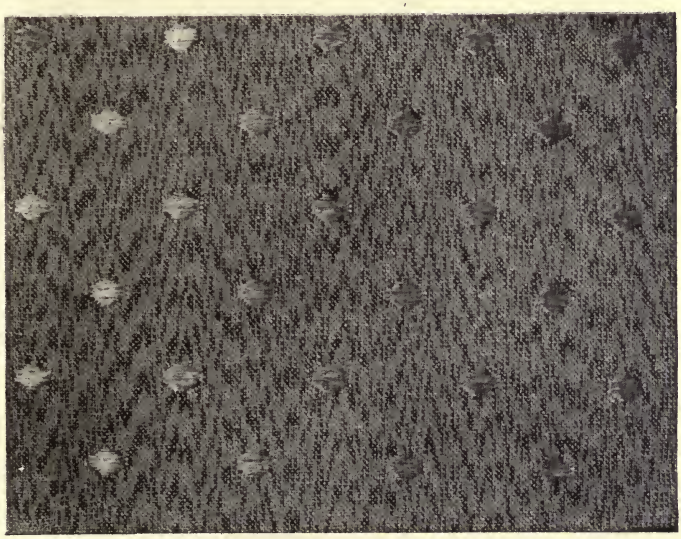


FIG. 158

serges, cords and other types of texture are now manufactured in agreement with fixed looming principles, and the use of prescribed warp and weft yarns, as they are dyed and finished according to a definite and approved system of work. Some of the looming data, which have gradually assumed a concrete shape, being based upon experimental investigations leading to established rules in factory operations, are tabulated on pages 248 and 249, as they concern the production of the principal classes and varieties of these fabrics.

TABLE XXIII

Systems of Lustre-Fabric Construction

A.—$^3/_4$-width Alpaca Linings

Warp.	* Sett.	Reed Width in Inches.	Picks per In.	Weft.
2/120's cotton	60's	33½	53	32's alpaca
2/120's ,, ...	60's	33½	58	36's ,,
2/140's ,, ...	64's	34	62	36's ,,
2/140's ,, ...	64's	34	66	36's ,,
2/150's ,, ...	68's	34½	70	40's ,,
2/150's ,, ...	68's	34½	74	40's ,,
2/160's ,, ...	72's	35	78	40's ,,
2/160's ,, ...	72's	35	82	44's ,,
2/170's ,, ...	76's	36½	86	44's ,,
2/170's ,, ...	76's	36½	90	46's ,,
2/200's ,, ...	84's	38	102	50's ,,
2/200's ,, ...	84's	38	106	50's ,,

B.—$^3/_4$-width Plain Lustres

Warp.	* Sett.	Reed Width in Inches.	Picks per In.	Weft Counts.
1/60's cotton	54's	32	56	32's
1/60's ,, ...	54's	32	58	36's
2/130's ,, ...	56's	32	58	36's
2/140's ,, ...	58's	32	64	36's
2/150's ,, ...	60's	33¼	66	36's
2/150's ,, ...	60's	34½	68	40's
2/160's ,, ...	62's	34½	72	44's
2/170's ,, ...	64's	35¼	74	44's
2/180's ,, ...	66's	35¼	78	46's

C.—Mohair Figures—$^3/_4$ Width

Warp.	* Sett.	Reed Width. in Inches.	Picks per In.	Weft. Counts.
2/80's cotton	58's	30½	64	32's
2/80's ,, ...	58's	,,	62	30's
2/100's ,, ...	62's	,,	62	30's
2/100's ,, ...	62's	,,	68	30's
2/100's ,, ...	62's	,,	68	32's
2/100's ,, ...	62's	,,	72	36's
2/100's ,, ...	62's	,,	80	40's

*Bradford or Dress-Trade System.

TABLE XXIII (*contd.*)

SYSTEMS OF LUSTRE-FABRIC CONSTRUCTION

D.—SERGES = 4/4 WIDTH

Warp.	* Sett.	Reed Width in Inches.	Picks per In.	Weft Counts.
1/32's cotton	50's	40¾	40	32's
1/34's ,, ...	50's	40¾	44	32's
1/36's ,, ...	50's	40¾	48	32's
1/40's ,, ...	60's	41	52	36's
1/40's ,, ...	60's	41	56	36's
1/45's ,, ...	62's	41¼	60	36's
1/50's ,, ...	62's	41¼	64	36's
1/55's ,, ...	64's	41½	68	40's
1/60's ,, ...	66's	41½	76	44's

E.—LUSTRES—58-INCH WIDTH

Warp.	* Sett.	Reed Width in Inches.	Picks per In.	Weft Counts.
2/120's cotton	54's	59½	56	32's
2/120's ,, ...	54's	,,	60	32's
2/130's ,, ...	58's	,,	60	36's
2/130's ,, ...	58's	,,	64	36's
2/140's ,, ...	60's	,,	64	36's
2/140's ,, ...	60's	,,	68	40's
2/150's ,, ...	62's	,,	68	40's
2/150's ,, ...	62's	,,	72	40's
2/160's ,, ...	64's	,,	74	44's
2/160's ,, ...	64's	,,	78	44's
2/170's ,, ...	66's	,,	80	46's
2/170's ,, ...	66's	,,	84	46's
2/180's ,, ...	68's	,,	86	48's
2/180's ,, ...	68's	,,	92	48's

F.—FIGURED LUSTRES—$^3/_4$ WIDTH

Warp.	* Sett.	Reed Width in Inches.	Picks per In.	Weft Counts.
1/40's cotton	58's	32	57	32's lustre
1/50's ,, ...	62's	32	62	38's ,,
1/50's ,, ...	62's	32	68	40's ,,
1/50's ,, ...	64's	32	72	40's ,,
2/110's ,, ...	64's	32	66	40's ,,
2/80's ,, ...	58's	30½	58	32's demi
2/80's ,, ...	64's	30½	61	36's ,,
1/36's ,, ...	54's	28½	62	32's ,,
2/40's ,, ...	50's	30½	60	32's ,,
1/32's ,, ...	46's	29½	44	32's ,,
2/100's ,, ...	58's	30½	68	36's ,,
2/100's ,, ...	60's	30½	76	36's ,,
2/100's ,, ...	58's	32½	68	36's ,,
1/50's ,, ...	36's	28½	40	36's ,,
1/56's ,, ...	36's	29½	46	36's ,,
1/36's ,, ...	36's	29½	48	32's ,,

* Bradford or Dress-Trade System.

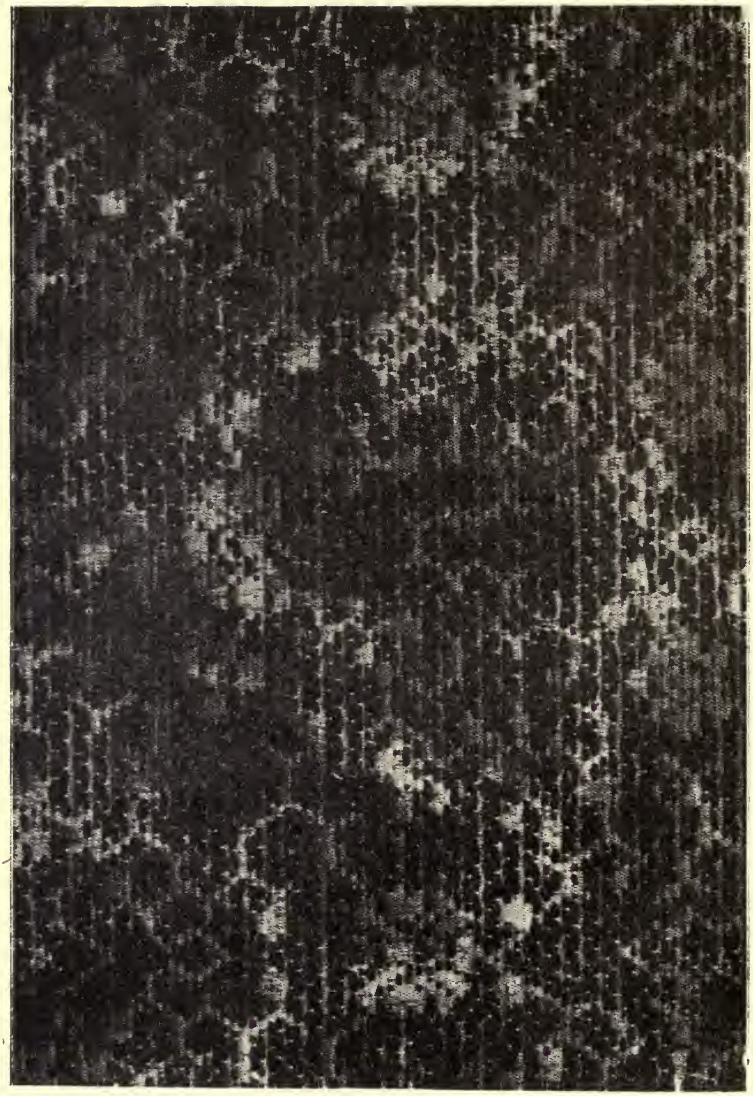


Fig. 159

176. *Glacés, Sicilians, Plain Orleans and Italians.*—The serges are also made in different widths, such as 58 in. in place

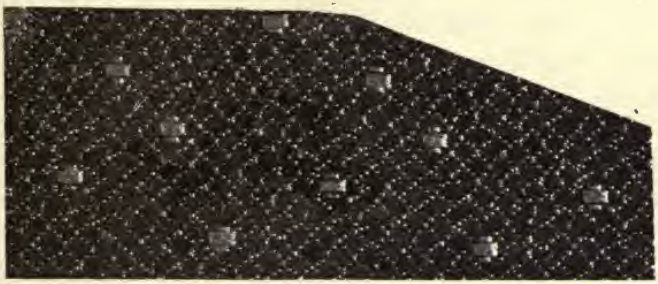


FIG. 160

of 36, setting 59 to 59¾ in. in the reed, and substituting 2/80's 2/90's, 2/100's and 2/120's, for the 40's, 45's, 50's and 60's

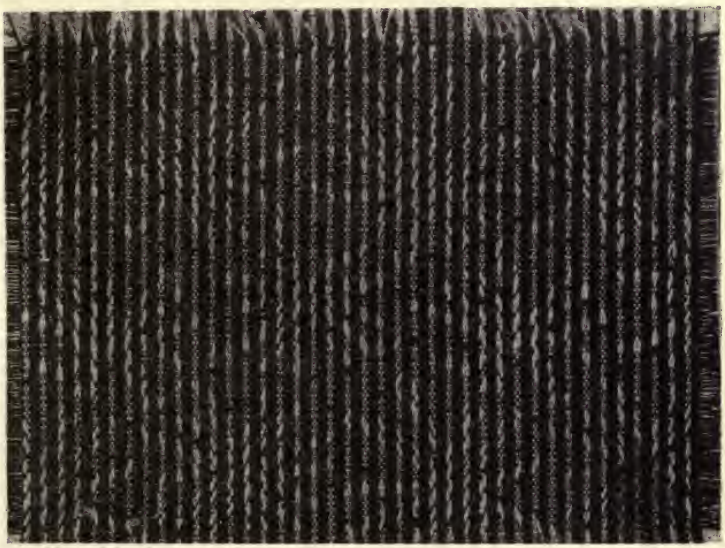


FIG. 161

single warp yarn, specified in Section D of the Table. Other special makes of these fabrics include glacés, Sicilians, plain Orleans and Italians. The following are given as examples

in methods of construction: *Glacés*—Warp, 2/80's cotton in 60's, 50's and 66's sett, 26¼, 30½, and 31½ in. in the reed, and wefted with 32's yarn with 60, 62, and 64 picks per inch; also in 60's 2-fold spun silk warp, 56's sett, 28 in. in the reed, and with 56 picks per inch of 30's worsted. *Sicilians*—2/80's cotton warp, 40's-60's sett, 28½ in. in the reed, and 44 picks per inch of 14's lustre; or 2/80's warp, 66's sett, 27½ in. in the reed and 64 picks per inch of 32's yarn. *Plain Orleans*—50's cotton warp in 48's and 50's sett, 24½ and 31½ in. in the reed with 52 and 62 picks per inch of 32's and 34's super demi worsted; or 50's warp in 50's and 54's setts, 33 and 34½ in. in the reed, crossed with 32's lustre, and with 62 and 70 picks per inch. Systems of looming for ¾ width *Italians* are given below—

(*a*)	2/80's	cotton warp,	99's	sett,	30	in. in the reed,	130	picks per in.,	56's	worsted	weft
(*b*)	2/80's	,, ,,	99's	,,	30	,, ,,	150	,, ,,	60's	,,	,,
(*c*)	2/90's	,, ,,	99's	,,	30½	,, ,,	170	,, ,,	65's	,,	,,
(*d*)	2/90's	,, ,,	99's	,,	30½	,, ,,	180	,, ,,	70's	,,	,,
(*e*)	2/100's	,, ,,	99's	,,	30½	,, ,,	200	,, ,,	70's	,,	,,
(*f*)	2/100's	,, ,,	99's	,,	31	,, ,,	210	,, ,,	75's	,,	,,
(*g*)	2/120's	,, ,,	99's	,,	31	,, ,,	220	,, ,,	75's	,,	,,
(*h*)	1/75's	,, ,,	90's	,,	32	,, ,,	110	,, ,,	56's	,,	,,
(*i*)	1/75's	,, ,,	90's	,,	32	,, ,,	110	,, ,,	56's	,,	,,

Other special varieties of fabric which may be made in one or more sorts of material, are the voile, zephyr, cashmere, flannelette and the grandelle. The two first are very light textures—plain woven—produced in such particulars as—

Voile, Warp and Weft, 2-fold 100's or 2-fold 80's with 90 or 70 ends and 60 or 46 picks per inch.
Zephyr, ,, ,, single 40's with 70 ends and 52 picks per inch.

A form of setting for the *cashmere* is 2-fold 60's cotton warp, 40 ends, and 60's Botany weft, with 72 picks on the inch. The fine-twilled flannelette is obtainable in 36's yarn woven with 78 threads and 62 picks per inch; and a type of *grandelle* in 2-fold 32's twist warp and 18's marl weft, having, in the loom, 96 threads and 64 shots to the inch.

177. *Russell Cords, Poplins, Repps, and Crêpes.*—As demonstrating the technical and weaving principles involved in these descriptions of union dress textures of a semi-lustrous quality, standardized data of production are specified on the two following pages.

TABLE XXIV

RUSSELL CORDS, POPLINS, REPPS, AND CRÊPES—EXAMPLES IN SETTING PRACTICE

RUSSELL CORDS—$^3/_4$ WIDTH

Weft.	Sett.	Reed Width in Inches.	Picks per Inch.	Weft Counts.
2/60's cotton . . .	58's	$31\frac{1}{4}$	60	34's demi
,, ,, . . .	,,	$31\frac{3}{4}$	72	32's ,,
,, ,, . . .	,,	$32\frac{3}{4}$	88	36's ,,
,, ,, . . .	,,	,,	100	40's lustre
,, ,, . . .	,,	$33\frac{3}{4}$	120	,, ,,
2/50's cotton . . .	52's	30	80	32's demi
,, ,, . . .	56's	$31\frac{1}{2}$	100	,, ,,
,, ,, . . .	54's	$32\frac{1}{2}$	112	,, ,,
1/30's cotton . . .	50's	$29\frac{1}{2}$	62	,, ,,
,, ,, . . .	,,	,,	68	,, ,,
,, ,, . . .	,,	,,	74	,, ,,

POPLINS

Warp.	Sett.	Reed Width in Inches.	Picks per Inch.	Weft Counts.
2/80's cotton . . .	72's	$26\frac{1}{2}$	66	28's worsted
2/40's ,, . . .	72's	27	68	28's ,,
2/50's ,, . . .	72's	28	62	28's ,,
2/40's ,, . . .	66's	$26\frac{1}{2}$	60	28's ,,
2/80's ,, . . .	60's–80's	29	40	14's ,,
2/60's ,, . . .	66's	$27\frac{1}{2}$	64	32's ,,
2/60's ,, . . .	66's	$27\frac{1}{2}$	56	24's ,,
2/50's ,, . . .	60's	27	54	32's ,,
3/40's ,, . . .	60's	$27\frac{1}{2}$	54	32's ,,

REPPS

Warp.	Sett.	Reed Width in Inches.	Picks per Inch.	Weft Counts.
2 ends (as one) of 2/40's cotton 1 end of 2/80's ,,	56's	$27\frac{1}{2}$	39	24's worsted
2 ends (as one) of 1/24's cotton 1 end of 2/80's ,,	56's	$21\frac{1}{2}$	40	34's ,,
3 ends (as one) of 2/40's cotton 1 end of 2/80's ,,	54's	$28\frac{1}{2}$	39	24's ,,
4 ends (as one) of 2/80's cotton 1 end of 2/80's ,,	66's	$28\frac{1}{2}$	44	24's ,,
3 ends (as one) of 2/60's cotton 1 end of 2/80's ,,	66's	$28\frac{1}{2}$	44	24's ,,
2 ends (as one) of 2/40's cotton 1 end of 2/80's ,,	72's	28	48	32's ,,

TABLE XXIV—(*contd.*)

CRÊPES—4/4 WIDTH

Warp.	Sett.	Reed Width in Inches.	Picks per Inch.	Weft Counts.
1/40's cotton . . .	62's	42	64	40's worsted
1/50's ,, . . .	62's	42½	70	40's ,,
1/50's ,, . . .	62's	43	76	44's ,,
1/55's ,, . . .	64's	43½	82	50's ,,
1/55's ,, . . .	64's	43½	90	54's ,,
1/60's ,, . . .	68's	44	100	56's ,,
1/60's ,, . . .	68's	45	108	56's ,,
1/65's ,, . . .	72's	46	112	60's ,,
1/65's ,, . . .	72's	46	120	60's ,,
1/65's ,, . . .	72's	46	128	64's ,,

178. *Designing Principles in Lustres.*—In lustre goods, constructed on the systems indicated in Table XXIII, the yarn

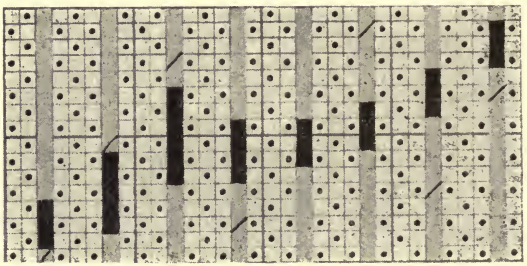


FIG. 159A

Sectional Structure for Fig. 159

characteristics determine the fabric structure and the design scheme or basis. A simple build of texture is, in this instance, made imperative, inasmuch as the warp yarns are restricted, in function, to knitting the weft shots together. On the other hand, the designs require to be planned to provide for the advantageous use of the weft yarn in forming a satisfactory ground fabric, and in clearly delineating the decorative features. Systems of work will be illustrated relative to: (1) manufactures in which the cotton warp threads are concealed by the weft yarns; (2) textures in which two or more types of weave are combined; and (3) figured styles having an elementary ground plan.

The idea, in the first principle of construction is to produce a surface pattern in the lustre yarn, which shall be so arranged as to give an evenly-constituted fabric. Two examples are shown in Figs. 151 and 151A, pages 237 and 238. Here it will be observed the warp intersections are limited, on the face, to single floats—an arrangement which yields a texture with a weft surface and a cotton-yarn effect on the under side. It is a practice which brings a maximum amount of the lustre yarn into view in the development of the design; but the fabric, unless the weaves are carefully planned, is liable to suffer in wearing durability. There is some scope for style origination, particularly in fancy twills, diagonals, diamond, rhomboid and transposition effects. The basic plans may also be varied in the looming. For example, the twilled lines, immediately adjoining the sections printed in grey, Fig. 151A, might be changed to plain, or these sections might be woven in heavier weft interlacings, and both alterations would definitely modify the textural pattern.

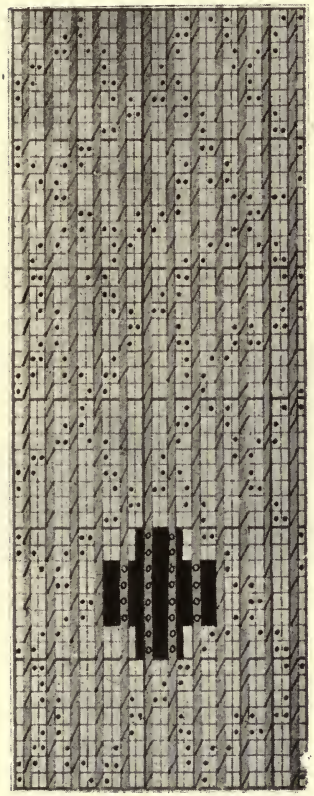


FIG. 160A
Sectional Plan for Fig. 160

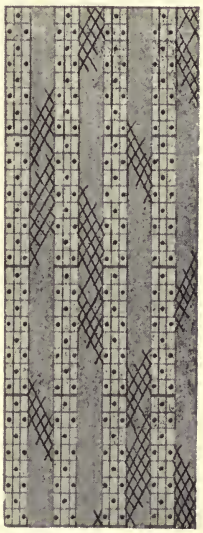


FIG. 161A
Sectional Plan for Fig. 161

179. *Pattern as a Resultant of Weave Elements.*—In the second

scheme of production, contrasts in weave elements are admissible, resulting in a bold, pronounced description of design. Three suggestive illustrations are supplied in Figs. 152, 152A, and 152B, pages 238 and 240. Fig. 152 is composed of two stripings, A and B, the first consisting of a diaper pattern, and the second of plain intertexture. The latter should form the larger quantity, allowing of the space it fills in the fabric, being variously coloured in the warp. When this method of weaving is practised, the goods are not piece-dyed, but finished in the

FIG. 162

same tints and shades as woven. Fig. 152A is of a different character, and typical of striped weave compounds in which a small twilled effect is continued into the special feature in the style : the difference in weave formation is less marked, as regards the disparity in the intersections of the two crossings combined, than in the succeeding example, but the textural distinctions are none the less evident in the pattern. This is observed on examining the two effects, C and D in Fig. 152A, that in C being a clearly-defined twill, and that in D a weft diamond, or two weaves as dissimilar in structural elements as the two used in the composition of Fig. 152. The third specimen, Fig. 152B, consists of crêpe and plain makes, an assortment of weave applicable to checks and stripes (dobbie and drafted patterns) and also to simple figured styles

constructed on a geometrical base. Usually the crêpe effects, as bringing a fuller percentage of the lustre yarn on to the face of the fabric than the plain weave or fine twill with which they are associated, form the principal parts of this variety of design.

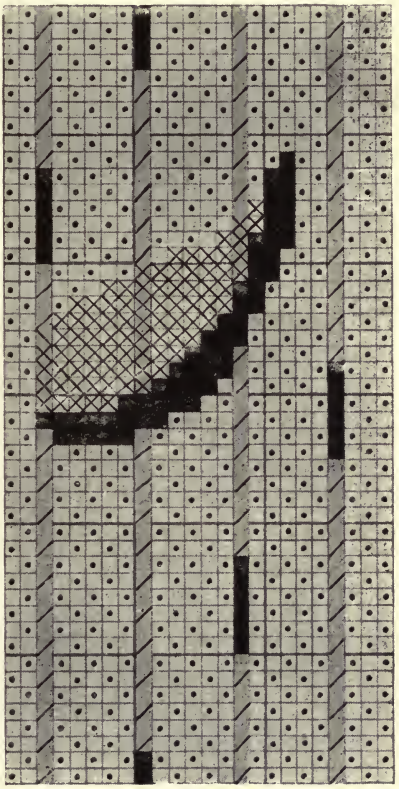


FIG. 162A
Sectional Plan for Fig. 162

180. *Alpaca Coatings.*—The alpaca coating (of which Fig. 153, page 241, is a woven example) if made of demi-lustre yarns—spun from the shorter-stapled material—is produced in weave types which float both the warp and the weft threads on the surface, including the derivative plans of the common twills, and plans of the twilled mat and common mat category. An illustration of the latter type is supplied in Fig. 154. It contains fourteen weft to ten warp intersections on each pick. With an increased ratio of warp units, the appearance of the texture is deteriorated. Though the weft yarn is, on an average, nearly as thick again as the counts of the warp when both are reduced to the same denominator, it is not sufficient to counterbalance the dulness of tone due to the cotton features in the manufacture. There is, therefore, a limit to which the warp threads should be employed in developing the details in this class of weave design. The plan shown may be taken as typical of the full number of the relative interlacings in which the two yarns are combinable. Adding to the weft factor

improves the surface quality, while adding to the warp factor detracts from the lustrous value of the piece.

For weaves of this order and also for those of the class exemplified in Figs. 151 and 151A, suitable looming particulars are as follows—

(1)	*Warp*,	2/80's	cotton,	58's	sett,	32½	in.	in the	reed;	*Weft*,	32's	demi,	50	picks per inch
(2)	„	2/90's	„	60's	„	33	„	„	; „	36's	„	54	„	„
(3)	„	2/100's	„	60's	„	34	„	„	; „	36's	„	60	„	„
(4)	„	2/110's	„	60's	„	35	„	„	; „	36's	„	64	„	„
(5)	„	2/120's	„	60's	„	35½	„	„	; „	40's	„	68	„	„

181. *Figured Lustres.*—These textures are more varied and interesting in design composition than the specimens considered. The ordinary grades of figured lustre fabrics have a plain ground, as in the example in Fig. 155, page 242, and for which a section of the looming design is sketched at Fig. 155A. The decorative elements are developed in solid floats of weft and in compact weft twills, The specimen in Fig. 156 is woven with a twill ground with the ornamentation in heavy weft twill and sateen, as indicated in the sectional plan, Fig. 156A. This principle of work is better adapted for acquiring newness of texture, and also freshness of pattern definition, than that illustrated in Fig. 155A. As a result of diversifying the weave structures, the floral forms and other elements in the design scheme may be clearly and suggestively executed.

Diversity of tinting in such "lustres" is to be obtained by cross-dyeing. The general practice is to dye the cotton and the lustre yarn the same shade, imparting a rich tone to the weft effects, but, in tinting the two yarns differently, the colour quality of the manufacture may be increasingly varied.

182. *Worsted Warp and Silk Weft Structures.*—Substituting silk for lustre worsted, mohair or alpaca weft, produces, in the same principle of looming as practised in the weaving of the classes of manufacture illustrated in Figs. 155 and 156—pages 243 and 244—a finer, softer, and richer quality of texture, which is further enhanced by the use of worsted in the place of cotton

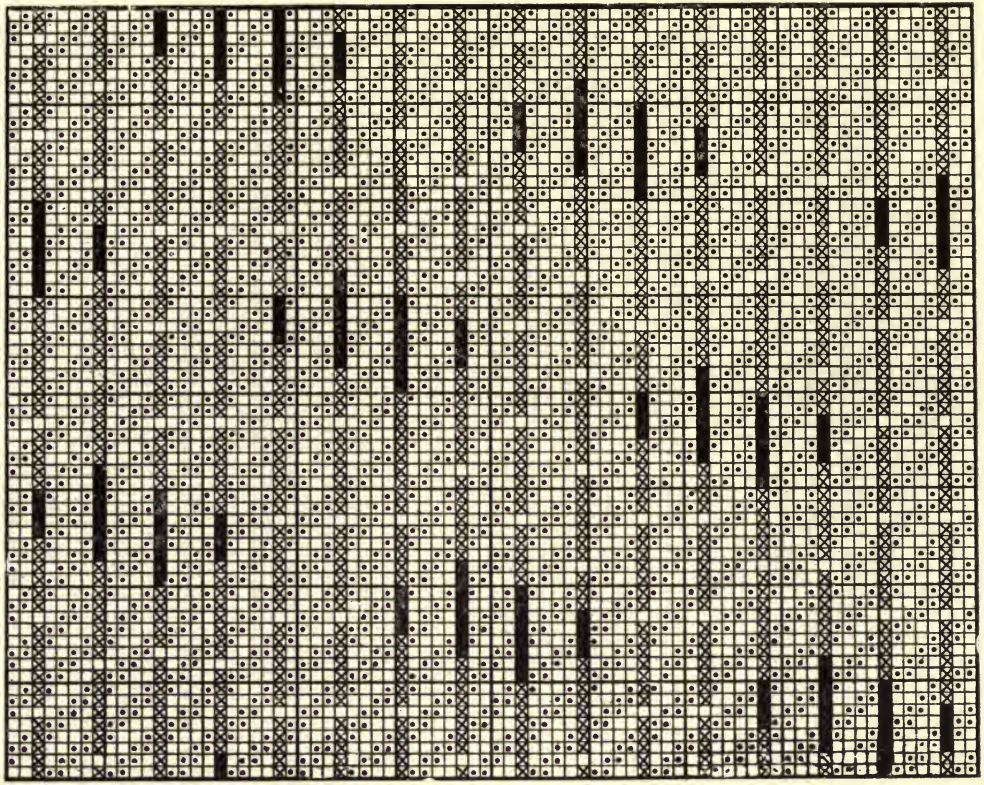


Fig. 163

warp yarns. Utilizing the plain weave for ground, and acquiring pattern definition by floating the weft yarn as in "lustres," a more flexible variety of fabric is obtained, specimens of which are illustrated in Figs. 157 and 158. It will be observed that some surface tinting of the texture is now developed by using coloured warp threads. The clearness of textural effect, which the silk and worsted yarns present in this simple scheme of weave combination—plain ground and flushed weft figuring—allows of such tinting in the warp without detracting from the tone and emphasis of the component parts of the design, woven in the solid floats of silk weft. The two examples are made in 2-fold 60's worsted warp, 60 ends and picks per inch, the weft being 40's silk. For Fig. 157 the warp is arranged six threads of black and six threads of black and white print yarn, and for Fig. 158 it is composed entirely of printed threads in white and a pale tint of green. The design for the former is shown at Fig. 157A, and that for the latter merely consist of spottings set at equal distances apart, with maximum and minimum weft intersections covering nine and three threads respectively in the warp.

A distinctive feature in Fig. 157 is the formation of the weft effects on the dark lines in the warp, leaving the detail in the intermediate stripings, woven in the printed threads, an interesting characteristic of the style. In Fig. 158 the ground of the texture—intermingled in tinting and marking—is a predominate quality of the structure. By one system of work, that practised in the production of the specimen in Fig. 157, each technicality in manufacture is valuable, yarn and shade contrasts, weave and pattern delineation; by the second system, that illustrated in Fig. 158, textural design, as a product of weft intersections, is secondary, being chiefly useful in adding diversity of composition to the line effects developed in the printed warp threads. Both textures are practically plain woven in the ground, and, as such, possess similar wearing qualities, but each is suggestive of a specific principle of design and scheme of surface tinting.

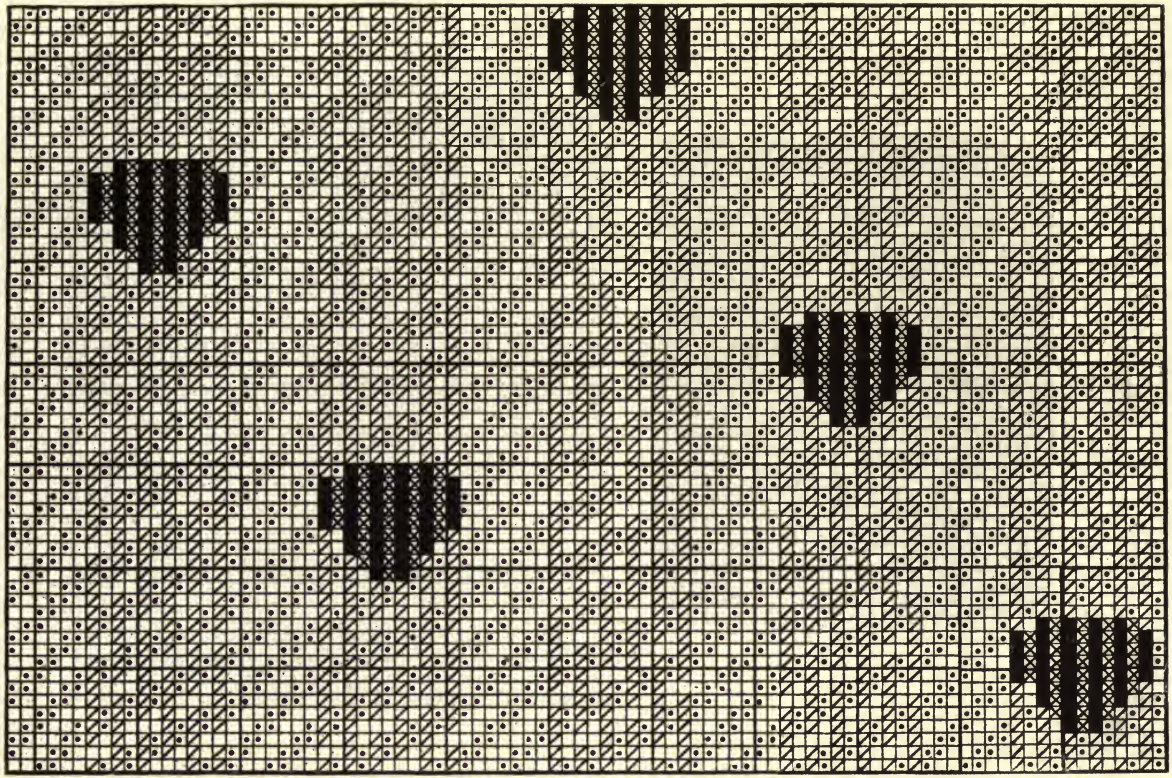


FIG. 164

183. *Worsted and Cotton Warp with Silk Weft for Pattern Production.*—Varying the construction of the fabric introduces a number of additional weaving elements into the

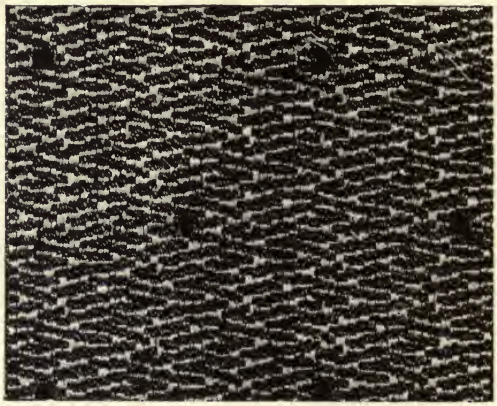


FIG. 165

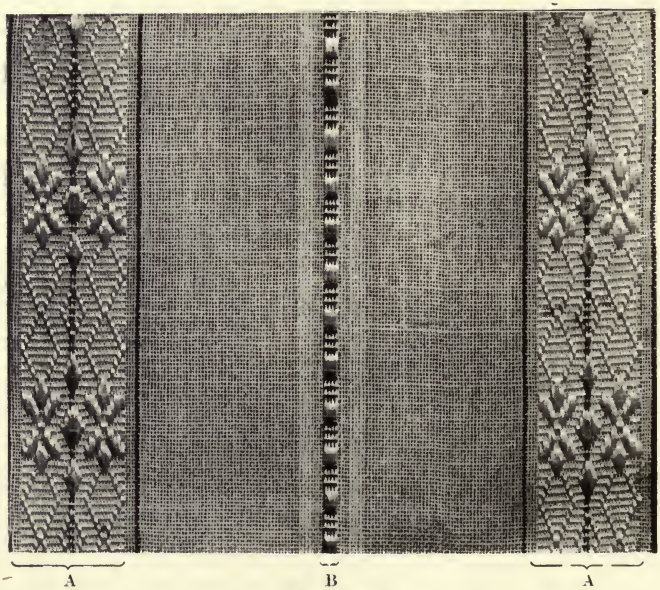


FIG. 166

designing practice. Two principal methods of manufacture may be examined which provide for the combination of

worsted, cotton and silk threads in the looming, namely, that in which the figuring is a resultant of the silk weft yarn, and that in which it is formed by the cotton warp and silk weft. Considering the first method, reference will be made to the

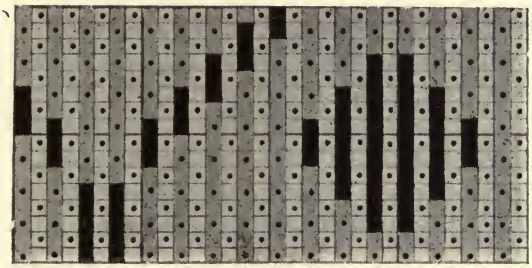


FIG. 166A
Sectional Plan for Fig. 166

specimens reproduced in Figs. 159 and 160, and for which the weaving data are as follows—

FIG. 159, PAGE 250. SECTIONAL PLAN, FIG. 159A, PAGE 254

Warp.

2 threads of 2-fold 80's cotton, white or tinted.
1 thread of 2-fold 40's worsted, dark shade.
1 ,, 2-fold 80's cotton, white or tinted.

Weft.

30's spun silk. Printed in several bright colours.
80 threads and 60 picks per inch.

FIG. 160, PAGE 251. SECTIONAL PLAN, FIG. 160A, PAGE 255

Warp.

1 thread of 2-fold 60's worsted, dark shade.
1 ,, 2-fold 60's cotton, black.
1 ,, 2-fold 60's worsted, dark shade.

Weft.

1 pick of 24's worsted.
1 ,, 30's spun silk.
84 threads and 84 picks per inch.

184. *Essentiality of Warping and Wefting Orders.*—The warping and wefting orders are an essential part of the composition and design of this class of woven union. They require

to be planned with the object of attaining economy of fabric production both as to actual weaving, and as to the advantageous use and application of the silk weft. In a given scheme of warping and shuttling, different fabric structures are formable, but this should be framed in relation to the qualities of yarn selected and the type of textural effect it is sought to acquire in each. Taking Fig. 159, the figuring is woven in the plain make, the ground sections being decorated with crimpled lines in worsted yarn. This denotes that the cotton ends and silk picks—dotted portions of the sectional plan, Fig. 159A, page 254—should be utilized in forming a plain texture which will be visible in the figuring by covering the worsted warp, and partially invisible in the ground sections by the worsted yarns being stitched loosely to the face of the plain-woven structure. If, in this specimen, white or a pale colour of silk weft had been applied instead of the variegated printed weft yarn, the ornamentative outlines and features would have been more clearly delineated, but the *ensemble* of effects would have been less diversified and also less interesting in tinted composition.

185. *Gimped-Yarn Ground Textures.*—Examining this design arrangement, it is two-ply in the warp and single in the weft, with, however, the figuring and ground of the fabric both produced in the same groups of threads and picks. The worsted yarns have a supplementary function. They are not used in making the texture proper, being spread on the face or on the back of the fabric produced in the cotton warp and the silk weft. This is effected by stitching the worsted threads—tinted grey in Plan 159A—in sateen order to the plain structure when appearing in the groundwork, and by similarly binding them with the cotton and silk interlacings when transferred to the reverse side of the pattern and flushed underneath the figuring. The difference in the diameters of the worsted as compared with the silk and cotton threads combined with the easy tensioning of the worsted warp in weaving, and the system of loosely stitching this yarn to the

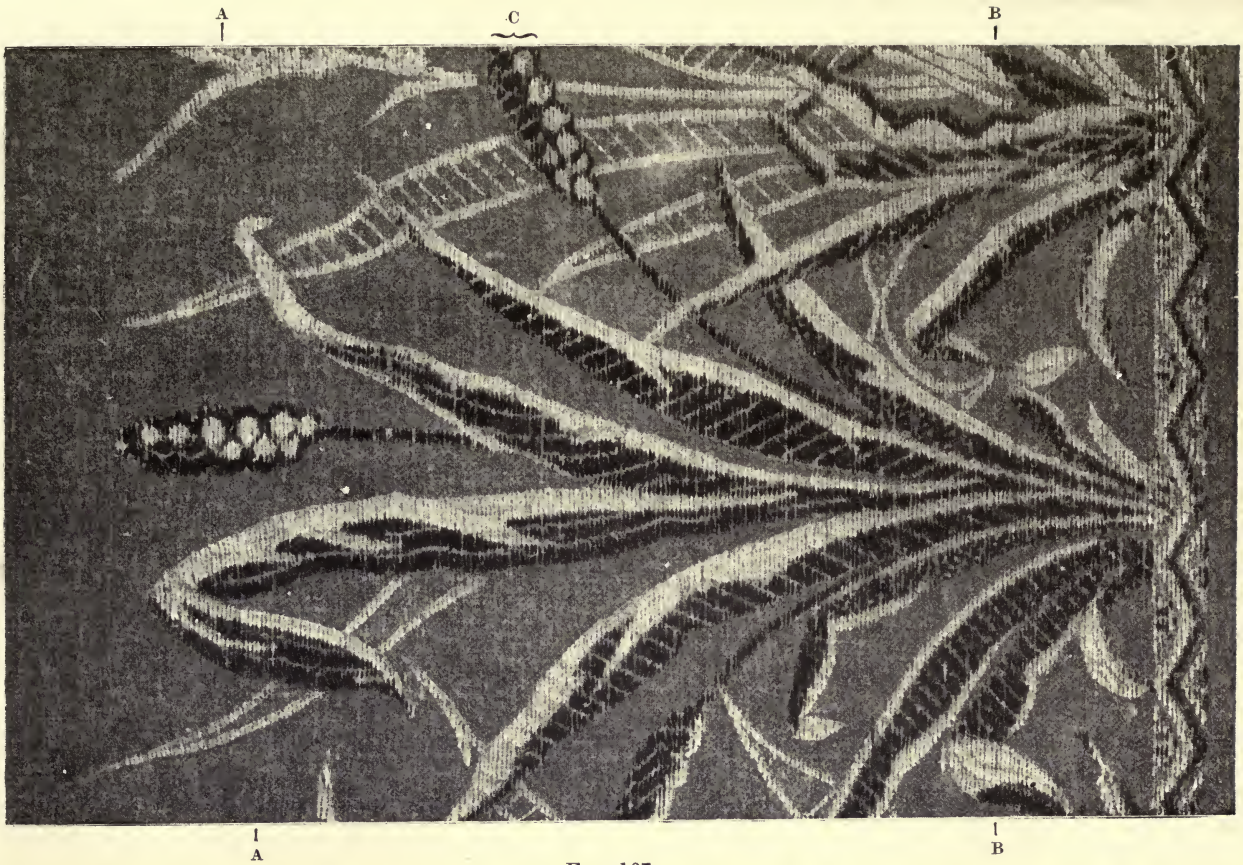


Fig. 167

surface of a fine, plain fabric, give rise to the design and textural contrasts observed in the specimen.

186. *Two-Ply Warp and Weft Thin Cloths.*—Fig. 160, page 251, is compound in the warp and in the weft but forms a light-build of union cloth in the yarns and loom setting specified. It illustrates the principle of construction in which worsted yarn is used in the warp and makes the face of the fabric, interweaving with silk weft for spotting or figuring and with worsted weft for the ground plan of effect. To this grouping of yarns a series of cotton warp threads are added, which intersect in plain order with both weft yarns, and thus yield a firm foundation texture regularly compacted with the worsted and silk structure. In the sectional design—Fig. 160A, page 255—the cotton warp threads are coloured grey and dotted, while the worsted threads are uncoloured and marked in ■'s at the points of intersection with the silk and worsted picks. The silk weft, in the spottings, covers both the cotton and the worsted warp ends, but in the line details it only covers the latter. The cotton threads, though interlaced in plain order, are well concealed by the thicker and more numerous worsted threads with which they are combined. The specimen is illustrative of the principle of looming for producing a thin, spotted or figured worsted warp and silk weft texture, having a warp weave effect in the ground, in combination with a plain cotton warp and worsted and silk weft structure, which imparts firmness and durability to the otherwise single build of fabric.

187. *Worsted and Silk-Warp Schemes of Intertexture.*—The application of silk in the warp to dress and other light textures, is effected on various principles, employing different orders of warping and plans of construction. A number of these will be analysed and illustrated. First, one economic practice consists in arranging the warp in alternate groups of worsted and silk yarn, as in the pattern sketched in Fig. 161 and for which a section of the working design is shown at Fig. 161A, page 255. The warp, in this instance, is made of 2-fold 60's

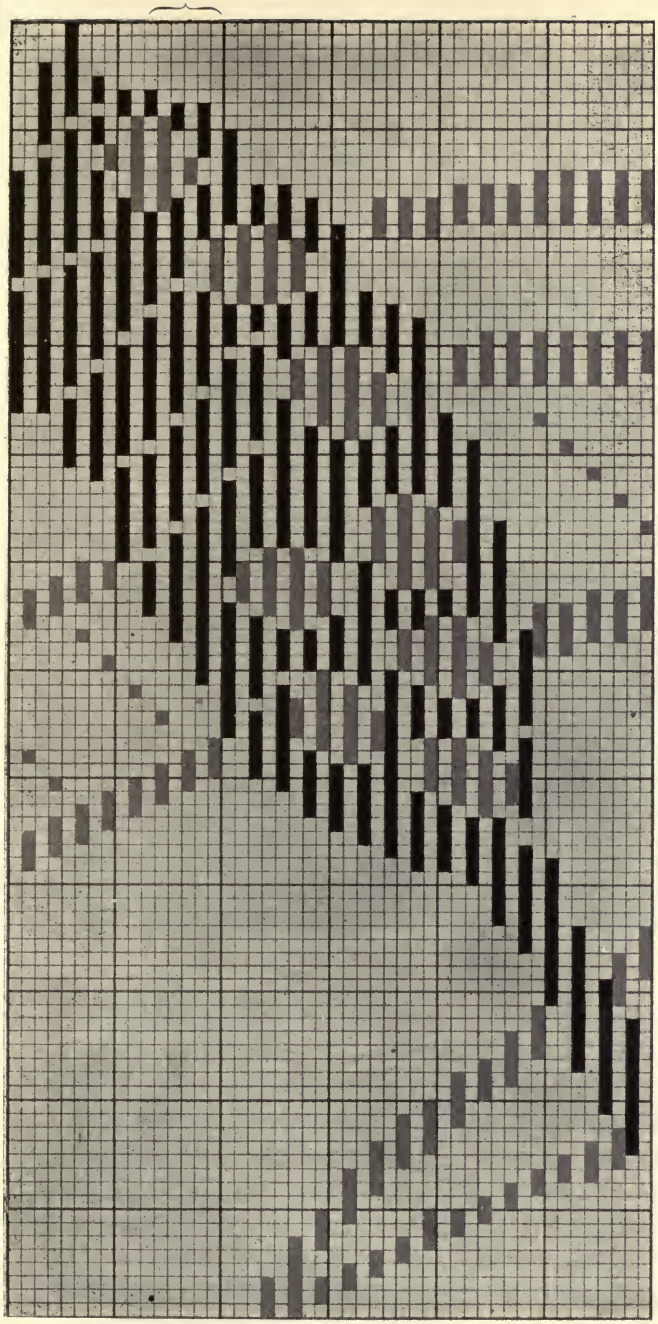


FIG. 167A
Plan of Section C showing Warp Figuring for Specimen 167

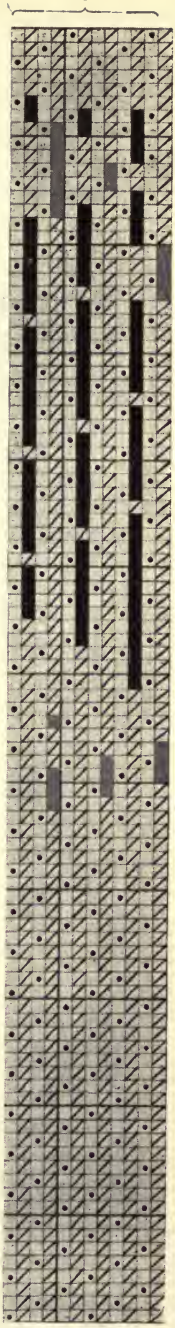


FIG. 167B
Section of Structural Plan for Fig. 167

worsted (dark shade) and 60's 2-fold white silk arranged 3-and-3 and wefted with 30's black worsted, the fabric having 72 threads and 48 picks per inch. Some breaking up of the pattern features is necessarily caused by this form of combination, but with the textures plain woven in the ground, and the figuring of a simple character, this is not regarded as detrimental, more especially if the design style should be adapted,

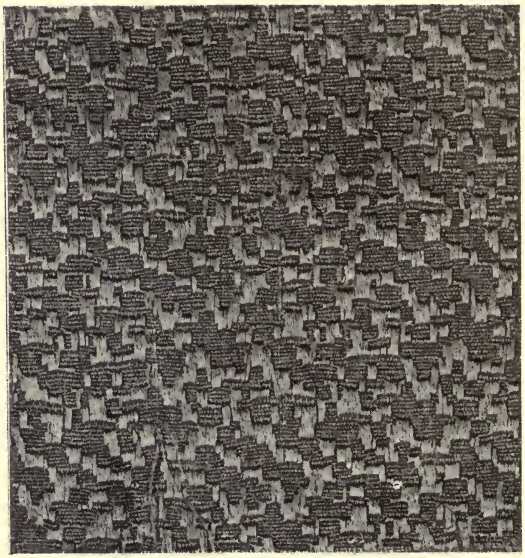


FIG. 168

as in the specimen, and as indicated in the sectional plan, Fig. 161A, to the warping scheme.

Using the silk threads for line effects and spotting, rather than for the formation of a considerable part of the fabric, the yarns are grouped on some similar system to that illustrated in Fig. 162, page 256, which results from warping 2 threads of 2-fold 60's worsted, 1 double thread of 40's 2-fold silk, and 3 threads of 2-fold 60's worsted; and from employing a plan constructed as shown in the section design, Fig. 162A, page 257. The weft is 30's worsted and the fabric has 78 ends and 56 picks

per inch. It adds to the value of the tinted quality of the pattern to use several colours of silk yarn in contrasting hues, and toning with the shades of worsted yarn making the ground of the pattern. Thus, in this example, figured in both the worsted warp and weft, the shades combined are a dark and light tone of green, with heliotrope, orange, lavender and pale green as silk spotting threads. The latter are irregularly distributed through the groundwork of Fig. 162 but they may be made to form an elementary or geometrical type of design. When the silk yarns occur more frequently in the warping, they are utilized in the development of distinctive pattern schemes on the worsted texture woven in twill, mat, or some simple weave plan. Two examples of this principle of manufacture are given in Figs. 163 and 164 for which the loom settings are as follows—

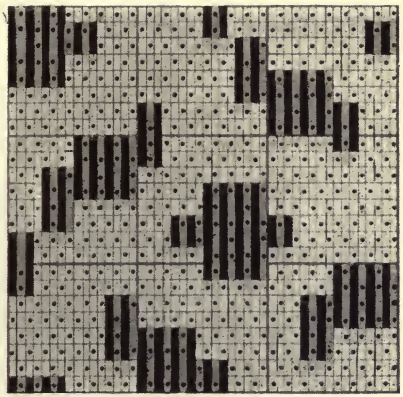


FIG. 168A
Sectional Plan for Fig. 168

FIG. 163, PAGE 259. *Warp.*

2 threads of 2-fold 48's worsted, dark shade.
1 thread of 30's 2-fold silk or mercerized cotton, Tint *a*.
2 threads of 2-fold 48's worsted, dark shade.
2 ,, 2-fold 48's worsted, light shade.
1 thread of 30's 2-fold silk or mercerized cotton, Tint *b*.
2 threads of 2-fold 48's worsted, light shade.
12's reed 5's.

Weft.

4 picks of 24's worsted, dark shade.
4 ,, 24's ,, light shade.
50 picks per inch.

FIG. 164, PAGE 261. *Warp.*

6 threads of 2-fold 56's worsted, light shade.

12 Threads { 1 thread of 40's 2-fold silk, bright colour.
1 ,, 2-fold 56's worsted, light shade.

Weft.

28's worsted medium shade.

72 worsted threads and 68 worsted picks per inch.

188. *Variations in Ground Characteristics.*—By the first of these arrangements, the worsted ground is checked in two

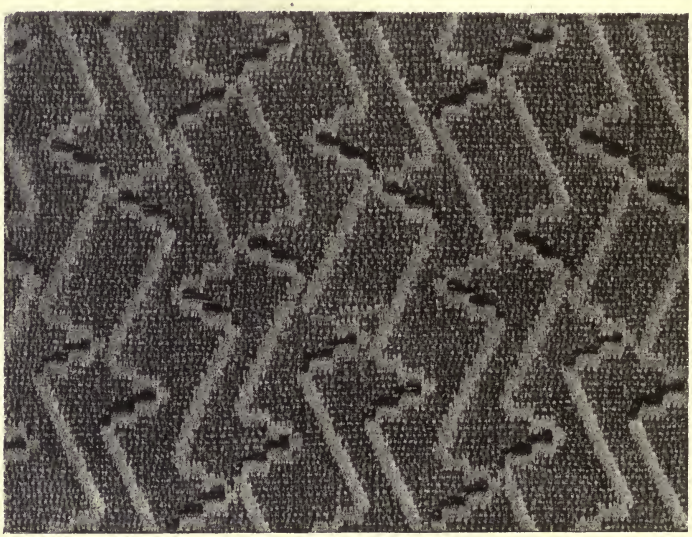


FIG. 169

shades and spotted with silk in the centre of each checked unit; and by the second arrangement, a twilled worsted texture, in a light shade of warp and a medium shade of weft, is spotted with the silk warp threads, which are evenly stitched on the under side of the fabric when not used in forming the effects on the face. Such pattern types—Figs. 163 and 164—are based on employing the silk as an extra or as a special warp yarn, and in this they differ from the method of yarn admixture in Fig. 161 and also in Fig. 165, pages 251 and 262. In the simpler orders of warping (3-and-3 in Fig. 161, and

1-and-1 in Fig. 165, woven in a similar plan to Fig. 139, page 227) ordinary weave principles are applicable, but in the treatment of the silk as an " extra " for the development of particular pattern elements, the weave structure becomes compound in the direction of the warp and single in the direction of the weft yarn.

189. *Cotton and Artificial Silk Example.*—The scheme of warp-yarn admixture—in which certain counts and qualities of yarn are used in the formation of the design, and other kinds of yarn in the ground of the fabric—is elaborated in the origination of figured stripe and border patterns. Two extensions of the scheme of this character are typified in Figs. 166 and 167—pages 262 and 265—one illustrative of textural effects and the second of decorative features as a part of piece manufacture.

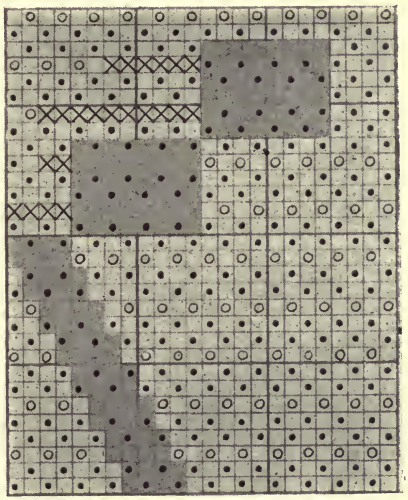


FIG. 169A
Sectional Plan for Fig. 169

Fig. 166 is woven in cotton and artificial silk yarns, the pattern being a product of varying the plan of interlacing the two sets of warp threads employed, arranged 1-and-1 in sections A and B, with the intervening spaces formed in plain weave. Fabric structure is the basis of the pattern features, their clearness of delineation being accentuated by the contrasts in the qualities and thicknesses of the yarns selected. Details in the artificial silk are also made distinctive in tone and definition by tensioning these threads separately, or to a lesser degree than the cotton threads used in the ground of the texture. With the same pattern woven in cotton yarns throughout, though the figuring and ground threads were differently

tinted, the resultant style would be flat in tone and deficient in textural quality. Design structure, as regards weaving principles, is of the variety described, consisting, as illustrated in the sectional plan, Fig. 166A—page 263—of floating the silk threads—tinted grey—on the surface in forming the pattern elements, and of interlacing them in plain order in the intervals with the cotton weft. As such threads are delivered under a low tension, they develop the design features in relief and also tint the ground of stripings A and B; while the plain sections, in cotton warp and weft, present a soft but duller colour toning.

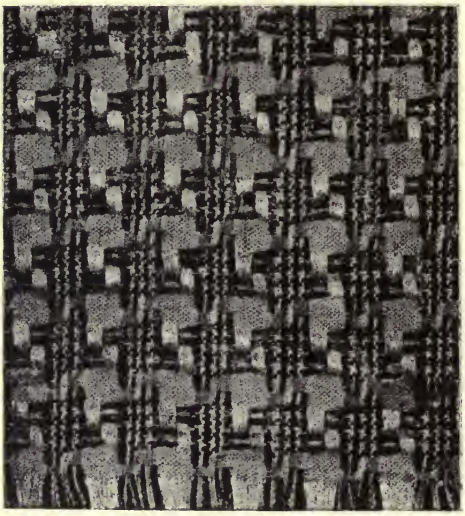


FIG. 170

190. *Border Patterns in Worsted and Silk-Warp Principle.*—Border designs, in costume and dress fabrics, are acquired in this weaving and warping scheme (Figs, 164 and 166), in which warp threads of a special quality are substituted, in end-and-end sequence, for the ordinary ground threads, employed in producing the textural characteristics in sections A and B of the last example. Controlling these in a prescribed order by the shedding motion of the dobbie, and by the method of entering them into the heald shafts, as also by special tensioning, they are usable at will in the construction of elementary design types. As there are no technical factors which prevent such effects from being developed at one edge of the piece, they may be applied in the origination of a bordered texture instead of in the manufacture of a cloth

striped or spotted in sectional parts, as in Figs. 162, 163, 164, and 166.

191. *Acquirement of Decorative Styles.*—Decorative styles are obtained in this make of union structure by using a harness and shaft mounting, the harness being utilized in the development of the border design, and the shafts in the construction of the piece or foundation fabric. Fig. 167—page 265—is a worsted costume or skirting with the border produced in extra warp

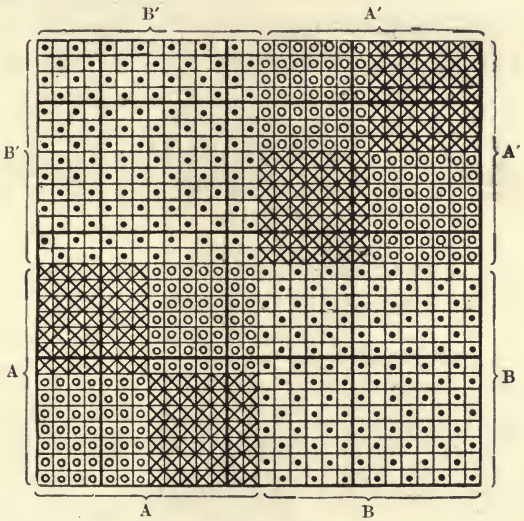


FIG. 170A
Design for Fig. 171

(silk and worsted) yarns operated by the Jacquard mechanism, and the piece yarns by either a small dobbie or a set of tappets. In the employment of two groups of warp yarns, delivered off separate beams, for figuring and ground purposes, the structure corresponds with the principle of loomwork practised in the weaving of the specimen in Fig. 160; but, whereas in the latter, the figuring yarns displace certain of the ordinary warp threads, here, as in Fig. 164, they form an additional element, allowing of the production of the twilled texture from side to side of the piece, that is in the figured and unfigured parts alike.

Figs. 167A and 167B—page 267—are sectional plans showing the cloth formation in the border. The twilling threads—

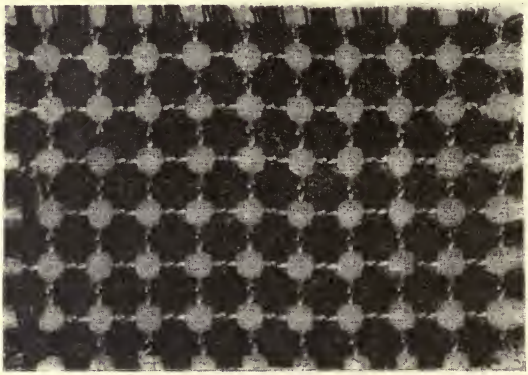


FIG. 171

marked in □'s, Fig. 167B—alternate with the figuring threads in black and grey—representing the dark and light tones in the pattern, woven in worsted and silk yarns. From these sections, it will be observed that the pattern yarns float successively on the face and back of the fabric, with the twilling threads intermediately arranged. Design preparation is done by transferring the sketch on to the point paper for the Jacquard mounting, the marked places—Fig. 167A—indicating the positions in which the threads of the figuring warp appear on the upper side of the cloth, and the blank sections the positions in the design where such threads float loosely on the underside of the piece. Stitching or binding ends might be used for securing the pattern-producing threads regularly to the ground structure, but, if employed, they should not be allowed to interfere with the even construction of the twilled weave. The importance of this point, and the technical

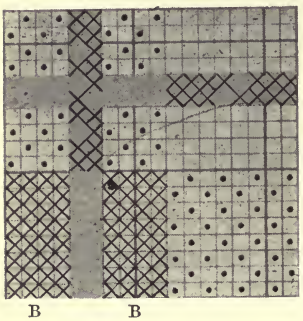


FIG. 171A
Plan of Fig. 171

difficulty of attaining it satisfactorily with the addition of special stitching yarns, will be understood on comparing the relative amount of ornamentation on lines A, A′ and B, B′ in Fig. 167, and in view of the fact that the ground make or twill is perfectly uniform in all parts of the border design. Using extra stitching threads tends to complicate the drafting of

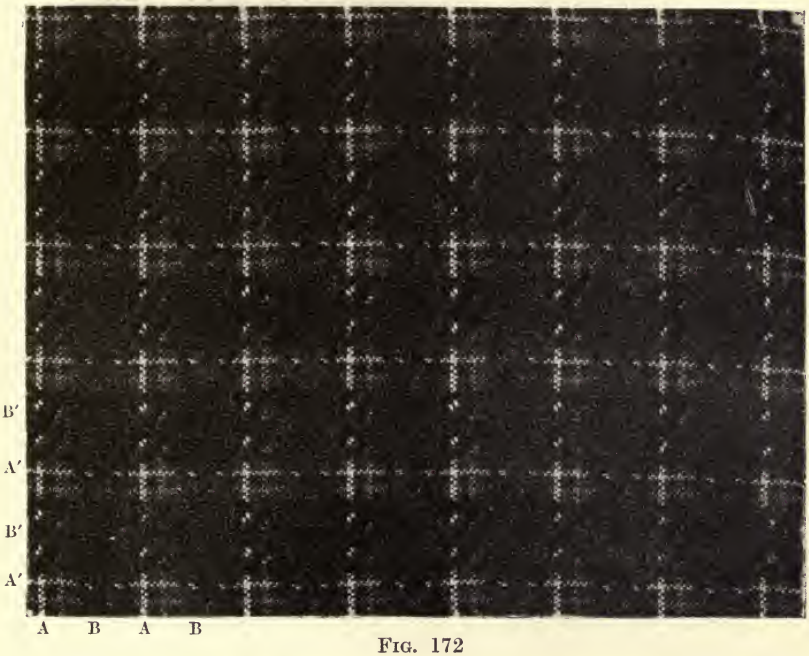


FIG. 172

the looming plan and the build of the fabric, and also to modify the accurate symmetry of the twill on the surface of the cloth, causing it to differ in appearance and in clearness from the same weave in the unfigured parts of the piece.

Silk and worsted yarns have been combined in the weaving of this border style, but mercerized cotton or artificial silk threads are also suitable; or the whole texture, ground as well as figuring, may be produced in cotton warp and worsted weft yarns. Linen threads are likewise applicable, changing

the build of the fabric to a plain make for the purpose of obtaining a greater degree of fineness of construction. Analogous tones of colouring have been selected in the weaving of the example, namely, fawn and deep fawn, as harmonizing with the medium pinky-brown mixture shade used in the production of the piece width. Large decorative effects, such as

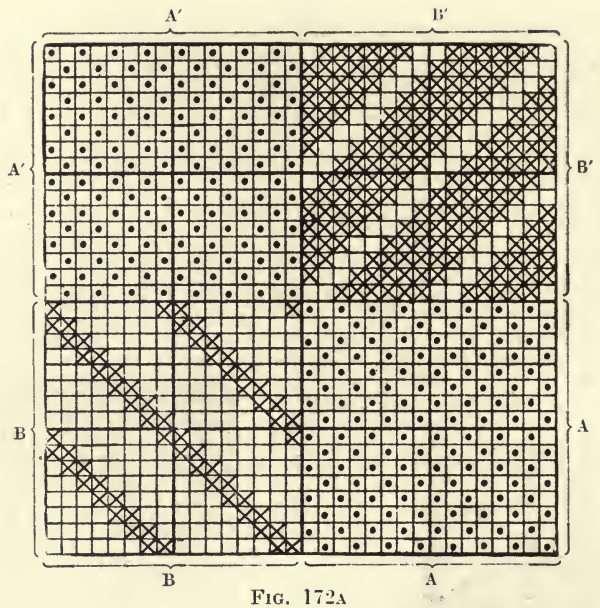


FIG. 172A

those illustrated in this specimen, may be more naturally linked with the groundwork of the cloth by practising tone-upon-tone colouring than by developing the pattern in contrasting hues.

192. *Silk Warp and Worsted Weft.*—The use of silk in the whole of the warp with worsted yarn as weft, may be advantageously carried out by varying the fabric build in some such form as exemplified in the specimen in Figs. 168 and 169, produced in designs constructed as shown in Figs. 168A and 169A, and in the following weaving data :

FIG. 168, PAGE 268. SECTIONAL PLAN, FIG. 168A, PAGE 269

Warp.

2 threads of 50's 2-fold silk, drawn in one mail.
1 thread of 60's 2-fold silk or 2-fold 60's mercerized cotton.
100 threads per inch.

Weft.

2-fold 50's worsted. 54 picks per inch.

FIG. 169, PAGE 270. SECTIONAL PLAN, FIG. 169A, PAGE 271

Warp.

All 60's 2-fold silk. 68 ends per inch.

Weft.

2 picks of 50's worsted.
1 pick of gimp yarn, made of 2 threads of 40's worsted twisted with 1 thread of 30's worsted.

193. *Warp Matelassé Type.*—Fig. 168 is a species of warp matelassé, and Fig. 169 of plain and flushed warp and weft weaving. The looming plan for the former is prepared by

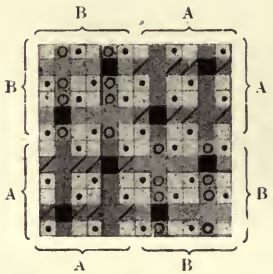


FIG. 173

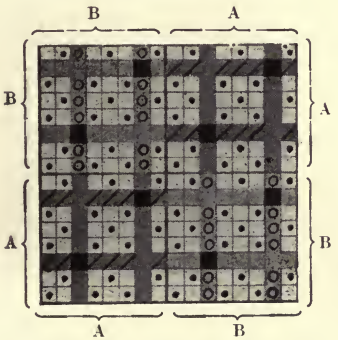


FIG. 174

outlining the pattern in colour (grey in the illustration) on the point-paper, and by marking the alternate threads (printed in black) for forming the silk details in the texture. The ground weave is plain, but, in using a thicker weft than warp yarn, a repped effect is produced. As the doubled silk ends—marked in ■'s in the design, Fig. 168A—appear on the surface in the development of the pattern, the single ends interweave with the weft 3-and-1 on the back of the fabric,

preventing the origination of loose floats, and resulting in a fast-woven structure. In Fig. 169, the gimp yarn (shown in ⊡'s in the plan, Fig. 169A) yields a kind of repp or cord groundwork and also certain line features (printed in ⊠'s), but the principal parts of the figuring are due to the fine worsted weft which forms a plain texture with the silk warp. The gim

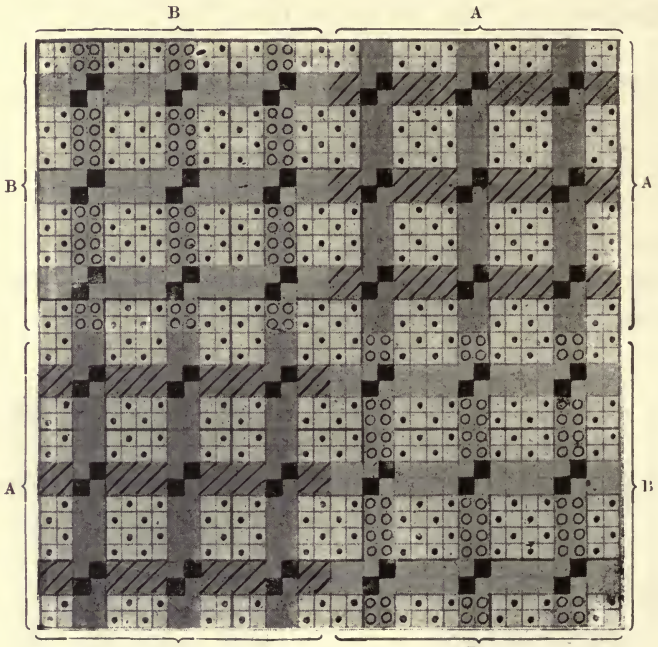


FIG. 175

yarn flushing in such plain sections on the under side of the fabric causes them to possess a raised and crepon appearance.

194. *Silk or Cotton and Worsted Yarns in Warp and Weft.*—The class of yarn admixture that will be analysed under this category, and in the following paragraph, is that obtainable in special weave structures formed in coincidence with particular systems of warping and wefting.

195. *Weave Units and Colour Arrangement.*—Primarily, the specimen in Fig. 170—page 272—is an example in open-mat

and plain weaves (Fig. 170A, page 273) in which the yarns are arranged : 14 threads of 60's 2-fold white silk (or mercerized cotton), and 2 threads of 2-fold 60's black and 2 threads of 2-fold 60's white worsted, for 14 threads. Sections A of the design are

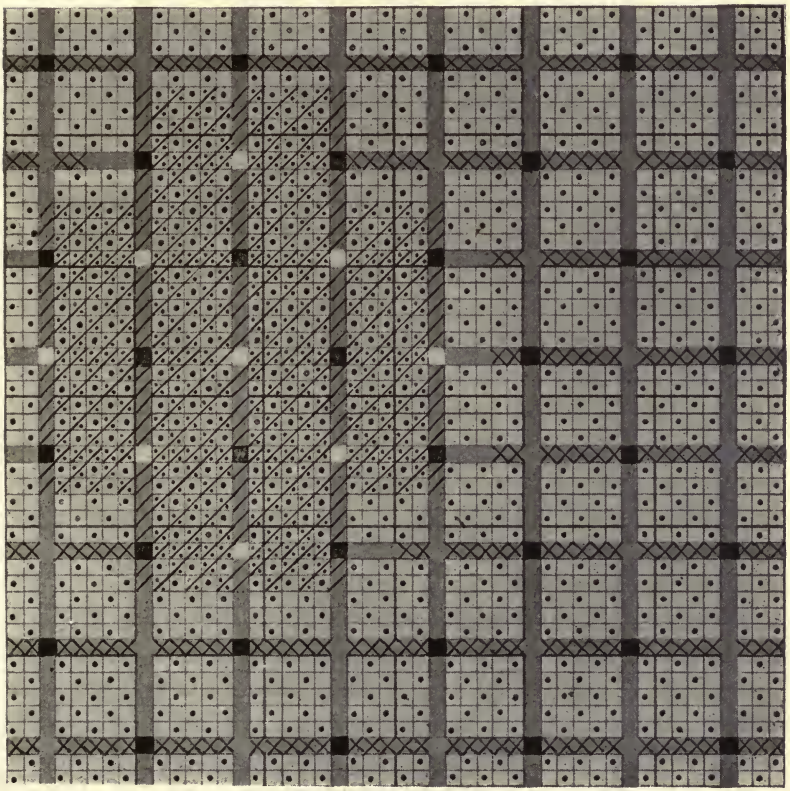


FIG. 176

woven in white silk and sections A′ in black and white worsted checkings. The effects, marked in ⊡'s in B, are woven in silk, and also those marked in ⊠'s in B′. The second illustration—Fig. 171, page 274—is interesting as showing how the weave plan (Fig. 171A) in combination with the order of colouring, arranged to fit with the intersection scheme, may be utilized in modifying the shape of the integral parts of the pattern.

There are clearly two sizes of rectangular spaces in the plain or dotted portions of the plan, and line and oblong features in the portions printed in □'s and in ⊠'s. The alteration of these to semi-circular forms in the style, is strictly due to the manner in which the fast-woven sections act upon the loosely interwoven ones, the parts formed in the black worsted threads and picks encroaching upon those formed in the white worsted (or cotton) yarns. The checking or divisional lines in silk help to define the shape of the spottings, and give character to the style. The order of warping and wefting consists of 4 threads of white (cotton or worsted), 2 threads of silk, 4 threads of white and 8 threads of black worsted. A radical basis of construction obtains in these types of woven design in the fast and comparatively open weaves combined, and in their arrangement with a view of developing the qualities of each yarn unit. This is seen, in the first instance, in the employment of the worsted yarns in forming the detail effects in black and white, and in the use of the silk threads in emphasizing the series of compact weft floats in B and the compact warp floats in B′ ; and, in the second instance, in the worsted warp and weft making the sections, in plain, adjacent with the sections in loosely-floated threads and picks, and in the influence which the former exert over the latter in the shaping of the pattern outlines, with the silk ends and shots producing overchecking lines in an intermediate scheme of intersection. The same principles of intertexture are applied in the third example (Fig. 172, page 275), but here the plain weave portions of the style are combined with sections composed of open warp and weft twills (Fig. 172A, page 276) one the reverse, in interlacing, of the other. This latter ingredient enables the colouring in A and A′ to be equally accentuated in the texture, and in marked contrast with the colouring in the plain portions of the design, B′. Parts B are formed in the ground shade or in the worsted yarns, the method of yarn assortment being : 16 threads of dark shade worsted ; 4 threads of silk or cotton, shade 1 ; 2 threads of silk, shade 2 ; 4 threads of silk, shade 3 ;

2 threads of silk, shade 2; and 4 threads of silk, shade 1, following with 16 threads of worsted, dark shade.

It should be noted that the weaving theory and practice here illustrated, are applicable to other yarn admixtures than

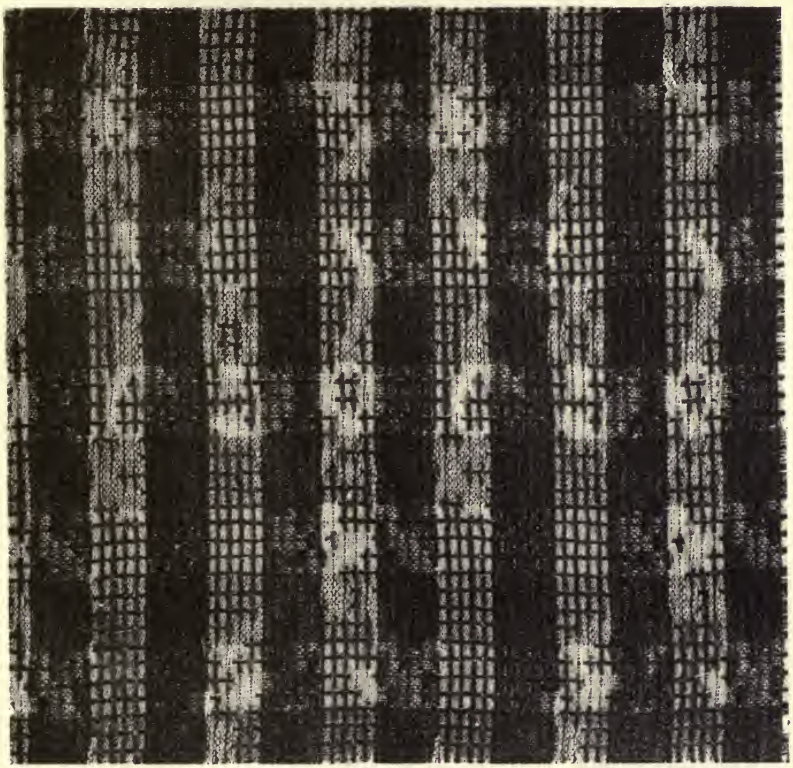


FIG. 177

those specified, such as linen in place of worsted, and mercerized cotton in place of silk, or cotton for worsted with artificial silk as a substitute for pure silk.

196. *Compound Light or Thin Fabrics formed in Open- and Fine-Set Structures.*—The use of compound weaves, in which two groups of warp and weft threads are employed, in the construction of two separate textures made into one fabric

light in structure, is facilitated by the selection of fine-spun yarns, and by the system of combining textures differing from

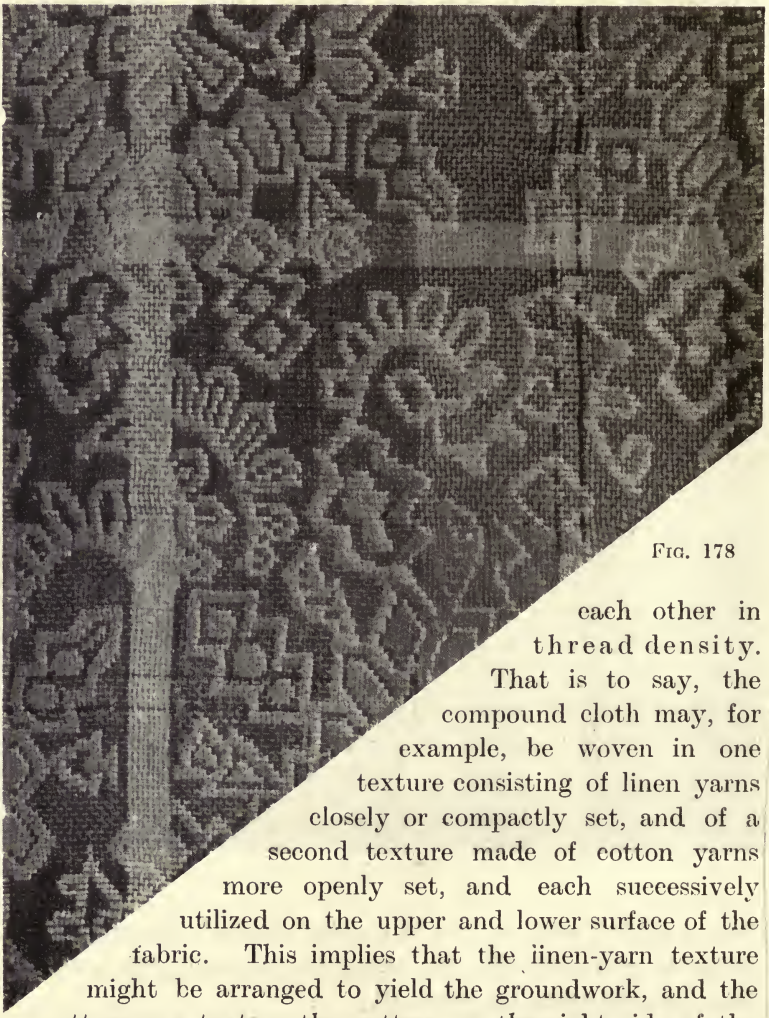


FIG. 178

each other in thread density. That is to say, the compound cloth may, for example, be woven in one texture consisting of linen yarns closely or compactly set, and of a second texture made of cotton yarns more openly set, and each successively utilized on the upper and lower surface of the fabric. This implies that the linen-yarn texture might be arranged to yield the groundwork, and the cotton-yarn texture the pattern on the right side of the woven product, which would give, on the reverse side, the figuring in the linen-yarn, and the ground in the cotton-yarn, structures. The respective textures are producible in

worsted and silk, worsted and mercerized cotton, silk or artificial silk and cotton or linen, as well as in yarns differing in fold, thickness, and in methods of preparation.

Plain weaves are preferably employed in the production of each structural type as in Figs. 173, 174, 175, and 176, which are respectively constructed on the 2-and-1, the 3-and-1, the 4-and-2, and the 5-and-1 basis; or they consist of duplex fabric structures of the relative thread densities in Figs. 173 and 175 of 2 : 1, in Fig. 174 of 3 : 1, and in Fig. 176 of 5 : 1, whatever the loom set practised. If the methods of looming indicated below, are examined in reference to these schemes of fabric combination, the principles of manufacture comprised will be more readily understood.

FIG. 173, PAGE 277

1 thread of 2-fold 60's cotton.
1 ,, 60's 2-fold silk.
1 ,, 2-fold 60's cotton.
120 ends and shots per inch.

FIG. 174, PAGE 277

2 threads of 2-fold 200's linen.
1 thread of 2-fold 70's cotton.
1 ,, ,, 2-fold 200's linen.
132 ends and shots per inch.

FIG. 175, PAGE 278

2 threads of 2-fold 56's worsted.
2 ,, 2-fold 40's mercerized cotton.
2 ,, 2-fold 56's worsted.
96 ends and 90 shots per inch.

FIG. 176, PAGE 279

2 threads of 40's 2-fold silk.
1 thread of 2-fold 30's cotton.
2 threads of 40's 2-fold silk.
150 ends and shots per inch.

197. *Analysis of Looming Practice.*—The tinted grey threads and picks, in the sectional plans, correspond to the open-set fabric, and the untinted threads and picks to the more compactly-set fabric, hence it follows that, in these weaving data,

the textural results obtainable would be as described in the following summary—

FIG. 173

Sections A. A plain-woven *silk* texture, (1), with 40 ends and picks per inch, spread over a finer-set plain-woven *cotton* texture, (2), containing 80 ends and picks per inch.

Sections B. Texture (2) covering and concealing texture (1).

FIG. 174

Sections A. A plain-woven *cotton* texture, (1), with 33 ends and picks per inch, spread over a finer-set plain-woven *linen* texture, (2), containing 99 ends and picks per inch.

Sections B. Texture (2) covering and concealing texture (1).

FIG. 175

Sections A. A plain-woven *mercerized cotton* texture, (1), with 32 ends and 30 picks per inch, spread over a finer-set plain-woven *worsted* texture, (2), containing 64 ends and 60 picks per inch.

Sections B. Texture (2) covering and concealing texture (1).

FIG. 176

Sections A. A plain-woven *cotton* texture, (1), with 30 ends and picks per inch, spread over a closely-set plain-woven *silk* texture, (2), containing 120 ends and picks per inch.

Sections B. Texture (2) covering and concealing texture (1).

198. *Surface Features.*—It will be understood that these are surface features only, and that, on the reverse side of the woven compound, the textural characteristics are transposed. The readiness with which the positions of the textures—open and close in formation—are interchangeable, in the construction of the design plan, enables pattern types to be, in this system of loomwork, developed by these methods. First, the decorative elements may be woven in the fine structure and the ground formed in the more loosely-set structure; second, the ground is producible in the open effect and the figuring in the finer-made fabric; and, third, the yarns of the open texture may be worked into a lace or net pattern in the ground portions of the fabric, and the ornamentative features formed in weft-face weaves, as in an ordinary single structure, and also in the yarns of the fine-set texture.

The first and third methods are applicable in the weaving of geometrical or floral styles, but the second method is principally practised in the origination of patterns simple in form

Fig. 179

and outline. In illustration of the yarns of the open texture being employed in the groundwork, Figs. 177 and 178 will be considered. The former is producible in cotton and silk and in the weaves arranged as in Fig. 176, and the latter in worsted and silk, combining plans A and B in Fig. 174. The

weave units, when analysed, show that, in the use of Plan A, the threads and picks tinted grey appear on the face, and, in the use of Plan B, they are transferred to the back of the fabric. Weave A spreads the loose-woven texture over the finer-woven one, and Weave B brings the yarns of the coarser structure on to the surface, in which relation they completely hide from view the interlacings of the yarns of the more open setting. Hence, having sketched, say, the pattern in Fig. 178 on the point-paper to the required scale, if the figuring is to be obtained in the silk-made, and the ground in the worsted-made structure, Weave A would be applied to the decorative, and Weave B to the ground parts of the design. Reversing the positions of the weave plans has the effect of changing the whole textural scheme, producing the figuring in worsted and the ground of the fabric in silk. In this instance it would prove a misappropriation of the silk texture, which, on account of its fineness and quality, is the better adapted for the development of the ornamentative details of the style. The worsted, if applied for this purpose, would result, in such a scheme of surface embellishment, in a less valuable textile product, one in which the figuring would be dulled in tone, and the fabric, as a compound of worsted and silk with the silk thread numerically the larger, qualitatively reduced. From which it will be evident that, in determining the structure in which the ground and the ornamentation are to be acquired, the yarns of which the two structures are composed, as well as the textural contrasts they originate, have to be taken into account. Should the pattern elements and composition be of a simple character with a fair amount of ground surface, the loosely-set texture may be selected for its production, but, as a rule, it is preferable to utilize the respective textures in the manner illustrated in Figs. 177 and 178.

199. *Net or Lace Grounds.*—The lace or fancy net ground type of combination is shown in Fig. 179. The grouping of the threads and picks of the two structures follows the principles of looming defined, selecting such arrangements as 5 ends

of the fine to 1 end of the open structure, and 7 or 9 threads of the close-woven to 1 thread of the loose-woven fabric. In the example, the 5-and-1 system of construction is practised,

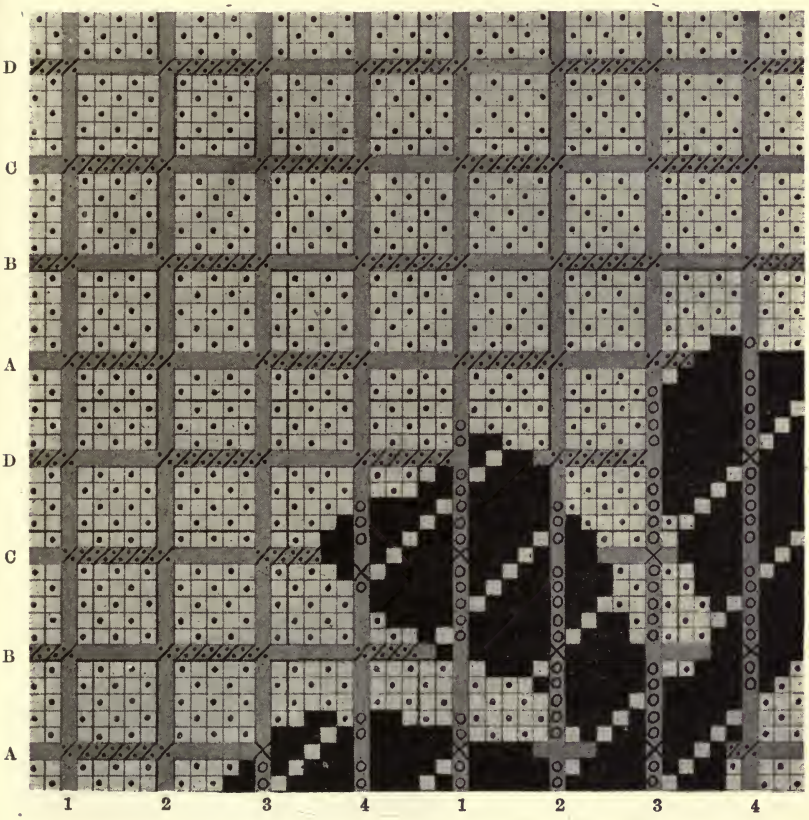


FIG. 179A

Sectional Design for Specimen 179

combining silk and mercerized cotton yarns. As an extra weft is used in the production of the design, the specimen is typical of the third scheme of textural practice, or of that in which the finer texture is used for the ground of the manufacture, with the threads of the loose texture developing a lace effect on its surface. Instead of these threads (Nos. 1, 2,

3, and 4, Fig. 179A) intersecting plain as in Figs. 173, 174, and 177A, they are linked thus—

Picks A and C, Fig. 179A, threads 1 and 2, and threads 3 and 4.
„ B „ D „ „ 1 „ 4 „ „ 2 „ 3.

On this basis, the threads are drawn together and apart on alternate picks, and thereby made to produce the lace or line details seen in the illustration, Fig. 179. Under the figuring (in ■'s in Fig. 179A) such threads work plain and give, on the back of the fabric, a plain net effect similar to that obtaining in the ground sections of Figs. 177 and 178.

FIG. 180

200. *Crepons.* — Waved, wrinkled, crimped or crepon-woven surfaces are made in worsted, silk, and in a combination of cotton, worsted and silk yarns. They might be defined as a species of crêpe. Frequently they are compound in structure, but in the simpler and less costly types, the effects are due to some peculiarity in the qualities and construction of the warp and weft threads selected. If, for example, yarns of dissimilar shrinking properties are interlaced on certain weaving principles, the surface of the texture in the washing or steaming will crimp or buckle. By uniting such threads with yarns varying in structure and in twine, and also in tension in the looming, the most elementary scheme of fabric build may be made to yield a crepon quality. Assuming, in illustration, the bulk of a texture to be composed of worsted yarns of a moderate softness and of small stripes of silk,

FIG. 181

edged with hard spun three-ply yarn under a less degree of tension than the worsted, it would, on leaving the loom, possess an uneven surface. Damping the piece would cause the worsted sections to shrink and the effects in the three-fold yarn to loop or curl, developing crimpness in the lines woven in silk. Again, if special worsted threads are arranged in a

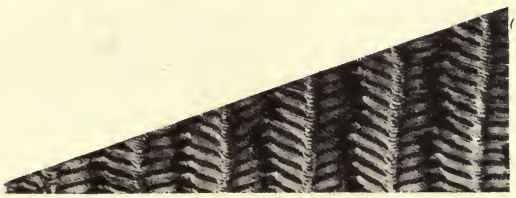


FIG. 182

striped or checked formation with silk threads (Fig. 180) and the fabric is plain woven, the worsted produces a canvas texture which, in the steaming process, contracts and imparts a wrinkled appearance and quality to the silk checkings.

201. *Characteristic Qualities of Surface Waviness in Fabrics.*— The crepon characteristic may vary from a mere waviness of surface to one consisting of well-pronounced undulations or ridges. To get the former, elementary weaves are applied, and yarns of different properties, especially as regards shrinkage disposition, are relied upon for the development of the required crimpness. If the *weft* threads are to form the crepon feature, the warp threads should be fine in counts, so that they will yield readily to the distinctive contracting action of the two or more kinds of yarn used in the shuttling. On the other hand, when the *warp* is the factor responsible for the production of the wrinkled surface, the weft may be the smaller thread. To take a typical fabric (Fig. 181) woven in 2-fold 80's cotton

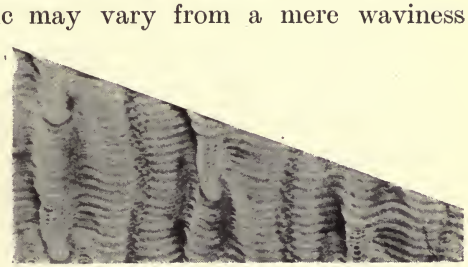


FIG. 182A

warp, and wefted 2 picks plain in silk, and 2 picks $\frac{1}{3}$ twill in 30's worsted, a slightly undulated surface is produced. The worsted, in piece cleansing and finishing, shrinks the texture in width, bending, in the process, the warp ends and crimpling the silk picks which, exercising little power of contraction, retain their normal or shuttled length. With the fabric decreasing from 30 to 24 in. in width—as a consequence of the felting induced by the quality of the wool fibre in the worsted yarn—the seven inches of each shot of silk are distributed on the surface of the texture in the form of a crepon or waved effect.

202. *Compound Weft-Weave Crepons.*—Compound weave crepons are richer and more diversified in textural features than single-weave structures. One general type (Fig. 182) consists of two wefts and one warp. If the foundation of this fabric is fast woven, the creasiness is caused by one of the wefts floating over—interweaving plain in the ground of the texture—and passing under successive groups of warp ends. The results are, first, when the picks float *under* the warp they draw the threads together, ridging the face of the fabric; and, second, when they float *over* the warp they likewise bring the threads into compact relation but wave and undulate the reverse side of the texture. If the warp and weft yarns in such a production should be of similar diameters, and spun from materials of the same nature and properties, the wavy development would be barely traceable. The floating weft is thicker, stronger, more elastic and shrinks better than the warp yarn, hence it draws the texture, formed by the latter and the ordinary picks, into ridges.

Moreover, but for the second series of picks—which are made of a comparatively inferior-shrinking class of fibre-interweaving plain, or $\frac{2}{1}$ twill, with the warp threads floated over or under the first series of picks as described, such threads would hang loose and not form a part of the woven structure; and, in addition, the smooth, rounded formation of the ridges would be less satisfactorily emphasized. From which it will

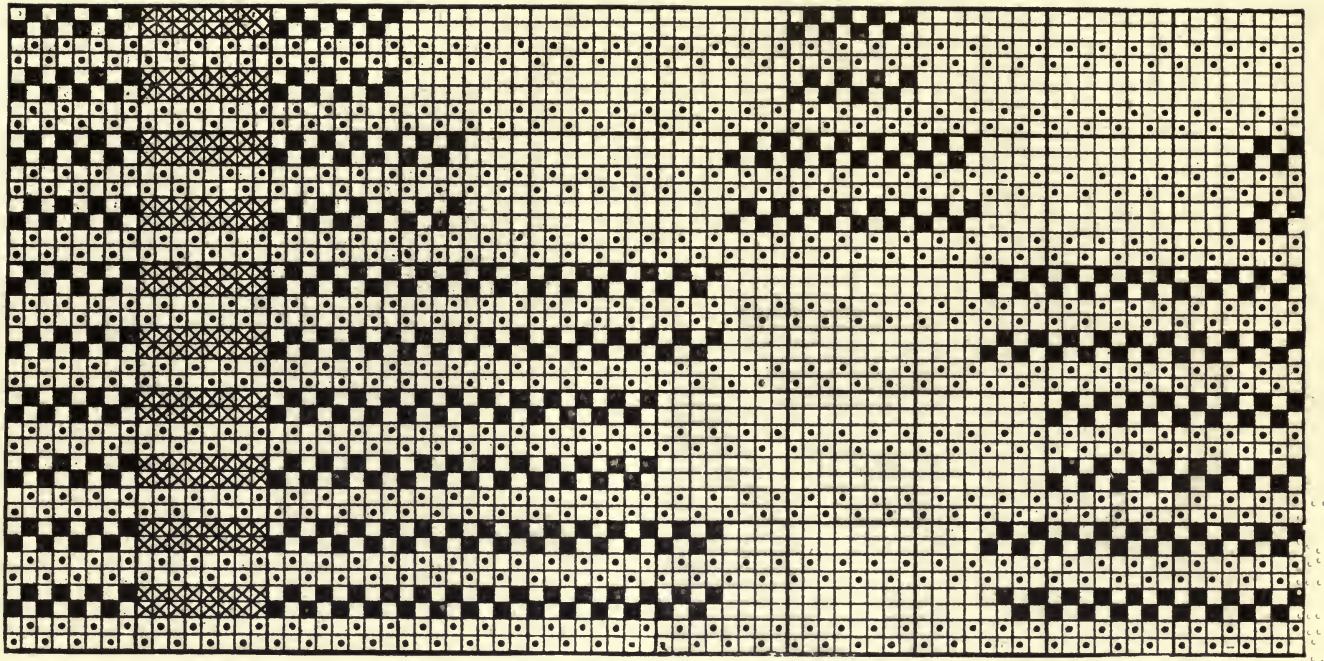


FIG. 182B

be clear that the fabric proper is made by the supplementary shuttling yarn, and the crepon quality by the floating weft. On the character and arrangement, therefore, of the floats, or flushed intersections, depends the nature and disposition of the wavy surface acquired. These may be arranged, as in Fig. 182A, to produce a broken and irregular figured effect. The sectional plan (Fig. 182B) shows that in such positions in the design as the weft yarn (marked in ■'s and ⊠'s) flushes on the face, it produces a series of undulations in the texture, and where it flushes on the back (marked □'s) it forms protrusions of warp on the face but plain interwoven by the picks marked in ⊡'s. With these two effects, combined with the plain ground-work, geometrical forms of patterns are developed in the fabric.

FIG. 184

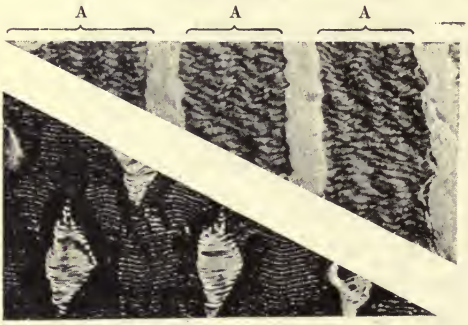


FIG. 183

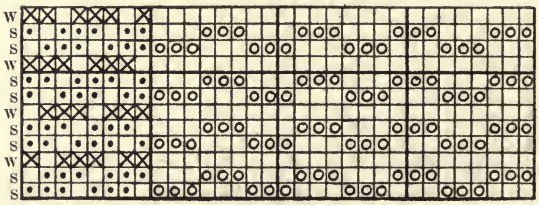


FIG. 184A
Sectional Plan for Fig. 184

The two specimens analysed in compound structures illustrate the principle of restricting one weft to the production of the ground, and the second weft to the acquirement of the crimpled or crepon effects in the manufacture. The next example, Fig. 183—looming plan section in Fig. 183A—is one in which the two wefts are also used, but both float, in

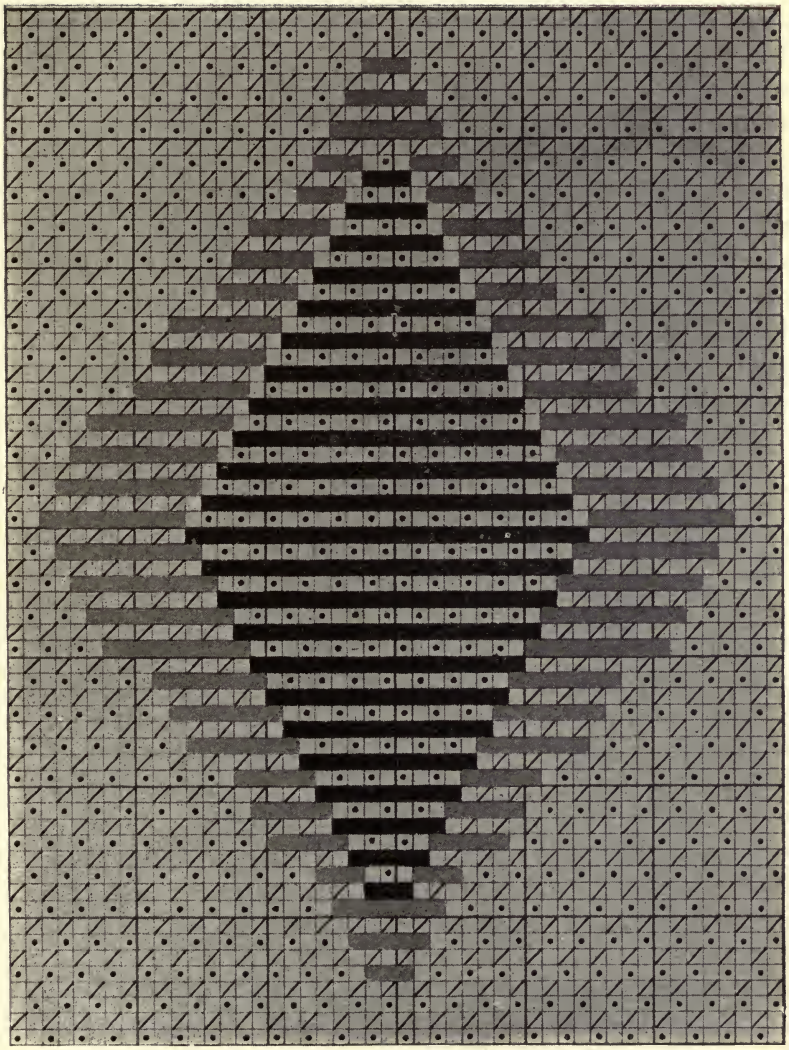


FIG. 183A
Sectional Design for Specimen 183

alternate order, over certain warp threads, and both, in succession, interweave plain. They have, in consequence, identical functions as regards pattern and textural origination. Unless, however, they were made of different fibres—one of wool and the other of silk—there would be little waviness visible in the texture, which demonstrates the importance of the relative shrinkage values of the yarns combined in obtaining these results. In the specimen the warp yarn is cotton, and the wefts worsted and silk shuttled pick and pick. When the former floats to make the spottings (▨'s in Fig. 183A) the silk weft intersects plain underneath, and similarly when the silk is floated in the composition of the interior figuring (■'s Fig. 183A) the worsted weft forms a plain underside, interlacing 1-and-1 with the warp threads.

203. *Modification of Weaving Plan.*—This combination of worsted and silk in two-weft crepons may be utilized, by varying the scheme of weaving, in the manufacture of different styles of striped patterns. An example is reproduced in Fig. 184, for which the structural plan is given in Fig. 184A. It consists of a band A in firm-spun worsted weft and fine cotton warp yarn, alternating with a narrower band in silk warp and weft, and which contains four times as many threads per inch as the worsted section. The silk picks (S, Fig. 184A) interweave regularly with the threads in both stripings, but the worsted picks pass beneath, or on the back, of the silk warp ends. The closely-set warp threads are longer than the cotton warp threads in bands A, and hence are wrinkled or waved the most. One other condition has to be taken into account: Two-thirds of the picks, namely the silk weft, intersect 3-and-3 with the worsted as well as with the silk, whereas the remaining third (W, Fig. 184A) only interlace, in twilled order, with the worsted warp. Now the more frequently a pick interlaces with the warp ends the longer it is. It therefore follows that the fine silk shots are actually slightly longer than the worsted. As the latter have a higher tensility, being thicker in counts, when the stretch is taken off

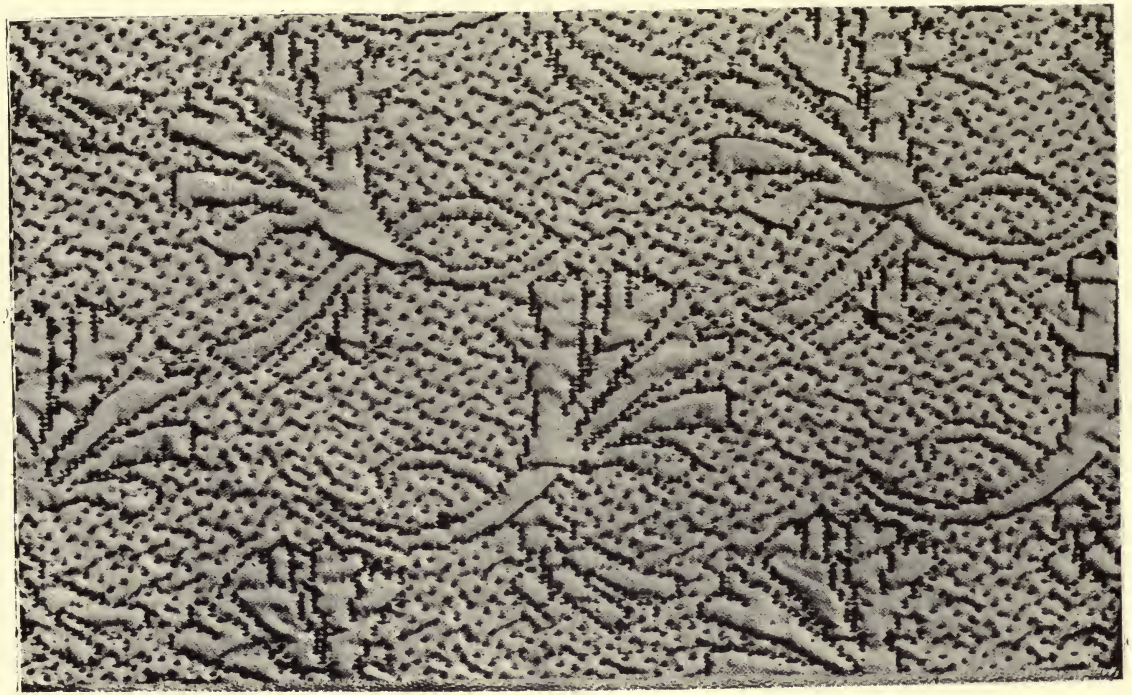


Fig. 185

the piece applied in the weaving, they at once crimp on the surface. By employing, as in this instance, a worsted weft spun from medium-stapled wool, and one of a gimped character, the crepon effect is increasingly pronounced. Weave structure, materials, yarn counts and quality, setting, and warp tensioning, are all factors which have an influence in the development of this type of waved-surface texture.

204. *Double-Weave Undulated Textures.*—Double-weave crepons may, as a rule, be distinguished by their greater density of structure and firmer feel as compared with single-weave fabrics. There is some scope, in this principle of construction, for the origination of figured styles. The fabrics possess two warps and two wefts. The yarns forming the underside of the texture may be utilized, at will, in figuring the face. It is a common system of design, but its application to crepons is accompanied by certain special conditions as to relative yarn thicknesses, loom setting, and stitching. The face and backing threads are generally silk and worsted respectively, and are arranged 2-and-1, 3-and-1, or 5-and-1, according to the character of the manufacture required, using plans of the types A and B in Figs. 173, 174, and 176, pages 277 and 279.

By this means a flimsy, gossamer, web-like texture is spread over a firmer fabric, to which it is loosely stitched at considerable intervals, and by which it is readily drawn or waved in a particular manner and direction. Where the bindings or stitchings occur the backing yarns come on to the surface, or the positions of the two groups of threads are reversed: where they do not occur, when the piece is allowed to shrink, which it does in some degree on leaving the loom, the thin, gauze-like texture, woven in the silk warp and weft, wrinkles, cockles or crepons. The finer and more flimsy the face fabric, and the more openly set and the tighter the backing yarns in weaving, the higher the shrinkage, and the better developed the crepon effect.

Various weave units are employed, but the most useful are based on the double plain. This weave, when arranged on

one of the methods indicated, is capable of producing the most interesting type of figured compound crepon structure. The specimen (Fig. 185) indicates the elements of textural design now observed. Primarily, there are in this pattern (*Warp* and *Weft*, 4 ends of 60's 2-fold silk and 1 end of 2-fold 60's worsted, 40's reed, sleyed 4-and-1 ; 120 picks per inch) two plain textures, one made of silk and the other of worsted, with the former containing 80 threads and picks, and the latter 20 threads and picks per inch. The figured features are obtained by transferring the worsted yarns, singly or in small multiples, on to the face of the fabric. In the spaces intervening the outlining of the pattern, the silk texture puckers freely. In such portions, the silk and worsted textures are quite separate—one spread over the other but the two linked together—and any fine-pointed instrument may be easily inserted between them. On the under side, there is not a corresponding puckering of the worsted texture in the unstitched sections, which points to the fact that the infrequency, or absence, of the stitches is not, in itself, sufficient to account for the crepon characteristic. The shrinking of the backing fabric, or of the worsted-yarn structure, is potential in inducing an otherwise level-woven tissue to assume a crinkled, deflected, and waved formation, but one soft, lustrous, and fluffy in appearance and handle.

Crepon designs for this description of double-make fabric, are prepared for the loom by sketching the pattern in colour on point-paper, and by applying a weave of the type A, Figs. 173 and 174, to the figuring, and a weave of the type B to the sections of the plan for the transference of the backing ends and shots from the under to the right side of the cloth, and which have the two-fold function of binding the two structures into one, and of delineating the pattern forms and details.

205. *Technique in Crepon Manufacture.*—It has been shown what an important part the nature of the fibre plays in the production of the salient qualities and features of these manufactures. In the weaving of all varieties and grades of

crepons, yarn of different shrinkage values are combined. The term shrinkage is not, as employed in this connection, synonymous with shrinkage as applied and understood in milling and felting, but it rather relates to, and defines, the contraction which transpires when a woven-product is released of all strain or tension necessary in the loom. On this being removed, worsted and woollen fabrics are slightly diminished in width and length. Silk, cotton, and linen pieces retain their loom dimensions to a fuller degree than those made of

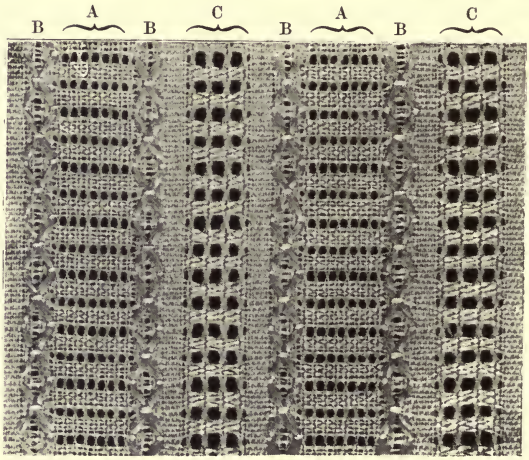


FIG. 186

woollen or worsted yarns. This differentiation in the contraction values of textile fibres and yarns, and of the fabrics in which they are used, is of fundamental significance in the production of crepons and like classes of fabrication. Given one kind of yarn which freely stretches in weaving, but has the power to regain its spun or normal length on tension being released, and another which stretches and contracts to a lesser degree, it is evidently feasible to amalgamate them on such principles as to cause the yarns of the increased shrinking efficiency to operate upon the non- or less-shrinking ones ; and also to an extent which will crease, bend, or wave the texture the latter produce. Supposing, for example, that a fine or

thin cotton texture, consisting of small threads, is stitched loosely to a worsted texture made of stronger and thicker yarns, both of which have been moderately tensioned in weaving, but the worsted under a greater strain than the

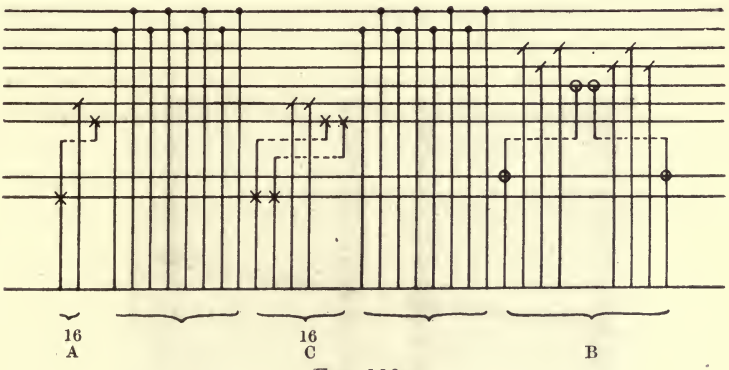


FIG. 186A

cotton, it is a problem of what must of necessity happen when the stretch on the compound structure is withdrawn. The worsted at once contracts, and, in doing so, folds and puckers the cotton texture with which it is covered in such places as the two fabrics are separate or distinct units ; and hence the creased or crepon character imparted in the finishing routine, or in the processes of cleansing and steaming. Thus the discrepancy, in the qualities of the materials forming the yarns, is of paramount importance in the development and permanent formation of the wrinkled surface distinguishing these textures.

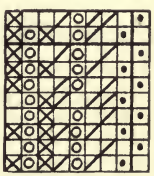


FIG. 186B

Next there is the question of the comparative counts or size and structural features of the yarns selected. If these did not vary largely, the contracting or controlling threads in the fabric, would not be of sufficient tensility to overpower the non-shrinking threads. Too thick or too strong a face yarn in compound crepons, will prove competent in neutralizing the puckered effects which the weave element,

and the materials, are designed to develop and emphasize. Generally speaking, when the crepons are single in structure and the waviness is a product of the weft, the warp yarns should be as small in diameter as to be weavable without breakage ; and, at the same time, one of the weft threads should be firm spun, so that it may readily corrugate the loose and light

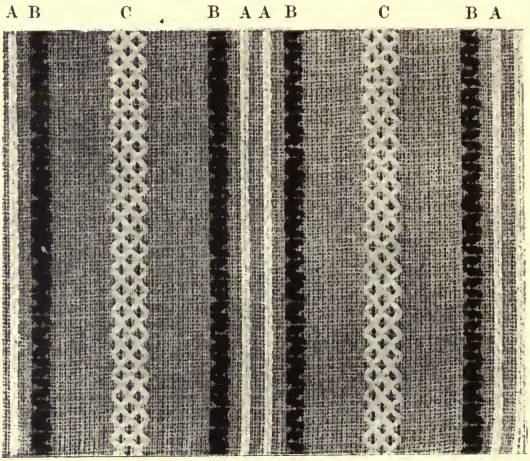


FIG. 187

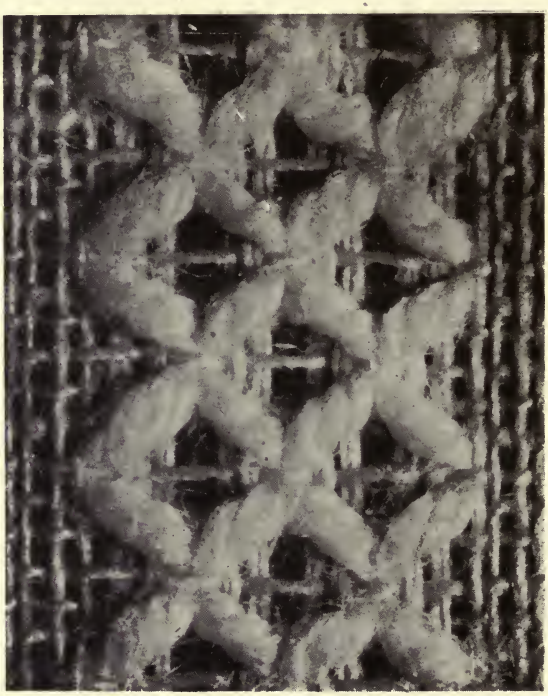
texture formed in the second weft and the second warp. In double-weave crepons, where at least two or three thicknesses of thread are necessary, namely, a fine and non-elastic face warp, a somewhat stronger weft for interweaving with it, and a firmer and thicker thread for the backing texture—it is the elasticity and tensile property in the yarns, giving the underneath surface of the fabric, which is responsible for the production of crepon characteristic. Should these yarns not be of the requisite stretching and shrinking efficiency, or be wanting in strength and thickness, the woven result would be imperfect.

The tensioning of the warp and weft yarns, in weaving, also influences the development of the wavy quality of the textural surface. A scheme of weaving, which, under certain

conditions as to comparative tightness of the yarns assorted, would be found satisfactory, may be rendered ineffective by the incorrect regulation of the tension applied to the warp and weft yarns. This is explicable on the ground that, in all classes of crepons, one set of warp and weft threads is required to crease or wrinkle the portions of the texture due to a second set of threads. As a rule, the tighter the creasing yarn units, and the slacker the non-creasing threads employed, the more pronounced the pattern obtained. Under this arrangement, the fuller tension is applied to the threads which possess the higher degree of elasticity, which augments their capacity, in puckering the unshrinking sections of the fabric, in the contraction induced after the piece leaves the loom.

When each technicality has been observed as to the use of yarns of a suitable quality and counts, and as to the adjustment of the tensions of the warp yarns, it remains to devise weaves whose structure will correspond with these data. Weave origination and construction are primary essentials. Single-make crepons are frequently formed on the basis of producing the groundwork of the textures plain or fast woven, whilst the wavy features in the pattern are obtained, as illustrated, by floating a particular series of threads or picks successively on the face or back of the fabric. It is almost impracticable to combine, in one texture, weaves composed of open and fast intersections without the latter, in some measure, causing surface creases; so that, by skilfully arranging weaves of this category, it becomes not only feasible to pucker the face of the pattern, but to accomplish this on prescribed lines. Compound weaves control the development of the crepon effects on a distinct system from single crossings. They admit, as shown, of the construction of two textures—one consisting of fine and unshrinkable yarns and making the upper surface; and the other consisting of thicker and shrinkable yarns, and making the lower or under surface. These two fabrics—which differ so markedly from each other in density, fineness, strength and elasticity—are loosely stitched

together. Hence, on the compound structure being allowed to contract naturally, or on being accelerated in the process by artificial means as in blowing the goods with steam, the firmer and shrinkable fabric creases and fashions into folds the thinner face texture, in consistency with the principles



C C C C

FIG. 188

fixed by the method of tying or stitching adopted and explained.

206. *Leno and Gauze Structures.*—Standard practices in the manufacture of leno, gauze and of "mock" or imitation makes of these fabrics, obtain in the combination of cotton and worsted, alpaca or mohair yarns, and in the employment of linen or cotton in the warp crossed with cotton or silk weft. The example in Fig. 186 is woven in a linen warp and cotton

weft yarn, with mercerized cotton ends for douping. Such types of fabric are also made with cotton as warp and silk as weft, using either folded silk or thick spun cotton for the effects seen at B. Another method consists in applying 2-fold worsted threads to the ground or warp threads shuttled

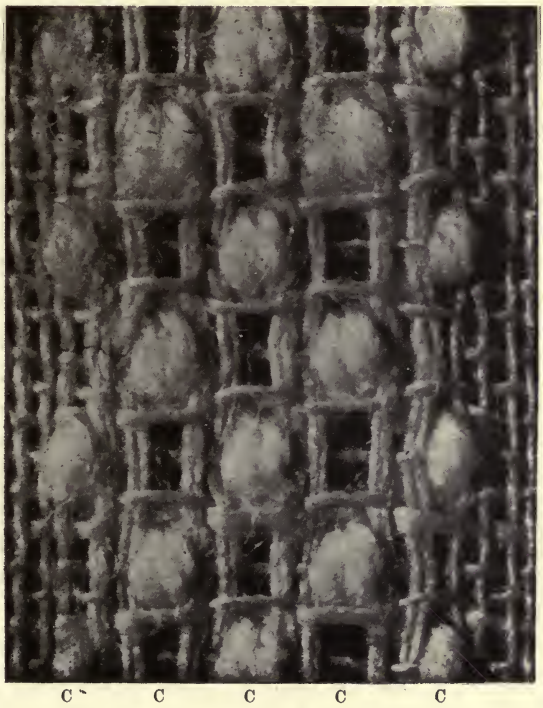


FIG. 188A

with silk, developing the prominent gauze stripings in cotton or linen yarns.

The looming draft and plan for this specimen are shown at Figs. 186A and 186B. The letters on the draft and specimen correspond. Threads A doupe with single ends, threads B with three ends, and threads C work in pairs and twist round two ordinary healded warp ends. For features A and C, there are several plain picks between each crossing of the doupe ends,

while the thick douping threads B are knitted to the surface of the texture on each fifth pick.

207. *Combinations of Lappet and Gauze.*—Pattern origination in gauze, lappet, and plain or straight weaving, provides for additional changes in the materials of which the yarns are spun. The lappet (dark sections in Fig. 187) being a surface warp yarn is quite a supplementary element, and is treated as such in the specimen. Here the white striping lines are formed in cotton, the plain bands in linen, the gauze details in mercerized threads, and the lappet features in worsted. A further principle obtains in employing worsted yarn in the warp and weft, with bright cotton threads for effects A and C and mohair yarn for effects B. With fine-cotton yarns for ground, intersecting plain or in sateen order, the lappet work is producible in silk, or in a lustrous-fibred thread, when the patterns may be, as in Fig. 189, of a decorative nature.

Fig. 189

208. *Microscopic Study of Gauze and Lappet Specimens.*—In Fig. 187 the striped gauze and lappet specimen is reproduced in the natural scale. Ordinary principles of comparison and dissection disclose the constructive elements. Supplementing such work by an examination of the fabric under the microscope (Figs, 188 and 188A), enables a fuller analytical study to be made of the structure. By this method, the actual mutation of the yarns, in forming the composite effects in the tissue and in the style, are rendered visible, and the technicalities observed in the adjustment of the

unit details, in relation to each other, become distinctly traceable.

Leno, gauze, lappet and imitation or woven lace effects are types of loomwork in which the delineation of the pattern forms is dependent on the overlapping latitude—traversing movement—of the special groups of warp yarns. On the plan originated and practised in controlling these threads, the character and accuracy of the textural product are mainly formulated. This is clearly evident in the specimens, Figs. 188 and 188A, the functions of the gauze threads C—accentuated in results by their greater thickness as compared with the plain interlacing threads—being not only apparent but individually readable as to the number of their intersections with the shots of weft. But, in addition to the precise woven scheme the microscopic examination supplies of the fabric, revealing its complete structural anatomy, from which deductions may be drawn, this method of textile analysis also elucidates the technicalities determined by yarn formations and fibrous properties. Their influence and value on the textural compound are evident in the tone and quality of each section of this example. Thus it will be obvious that, with the employment of threads of a smoother and more even surface, the distinctive features in the pattern would be more exactly defined, and this would add to the smartness and intrinsic merit of the woven structure as a whole. The obverse view of the sample—Fig. 188A—is valuable as showing the scheme of the binding points of the gauze threads C in the building of a regular, level texture, as well as exhibiting the details, in weaving this class of manufacture, which define the spacing of the warp yarns in the reed or sley.

CHAPTER X

STRUCTURAL SCHEMES—CLOTHS SUBSTANTIAL IN BUILD

209.—Features in Union Cloth Manufacture. 210.—Discovery of Methods of Utilizing Waste Fibrous Materials. 211.—Waste Fibre in Manufacturing Processes. 212.—Recovery of Filament from Spun Yarns and from Union Fabrics. 213.—Establishing a Distinctive System of Carding. 214.—Union-Cloth Construction. 215.—Incompleteness of Dyeing Procedure. 216.—Class and Grade of Union Trading. 217.—Single-Weave Unions and Concealment of the Cotton-Warp Yarn. 218.—Four Structural Types of Thick Manufactures. 219.—Weight-per-Yard Compass. 220.—Examples in Two- and Three-ply Weft Cloths. 221.—Sectional Drawings. 222.—Possible Distinctions in Face and Backing Weaves. 223.—Three-ply Weft Structures. 224.—Weaving Schemes—Multi-ply Weft Unions. 225.—Analysis of Wefting Data. 226.—The Use of Centre Weft Yarns. 227.—Colouring Practices. 228.—Application of Mixture-Yarn Shades. 229.—Worsted Warp, Cotton and Woollen Weft Types of Fabrication. 230.—Diagramatic Examples. 231.—Setting Practices. 232.—Cloth Quality in Bi-Wefted and in Cotton and Worsted Warp Unions. 233.—Two-ply Warp Union Specimens. 234.—Productive Economics and Weave Plans. 235.—Structural Arrangements and Fabric Substance and Thickness. 236.—Double-make Unions—Wadded. 237.—Union Compound Cloths with Outer and Inner layers of Yarn. 238.—Three-ply Manufactures—Sectionally illustrated.

209. *Features in Union Cloth Manufacture.*—Woven union cloth manufacture is a progressive section of the textile industry. It is of English origin, formation, and making. That the foundations of the trade were wrought, and that the means of development were systematized and applied by British endeavour, ingenuity and industrial competency, are matters of history. From an early date, union fabrics have been produced in great variety in dress stuffs, and in heavy woollens, including overcoating cloths, blankets and rugs. For some decades preceding the commercial manufacture, on a large scale, of these representative groups of union products on the Continent and in America, the former (dress textures) were the staple industry of Bradford and Keighley, and the

latter (thick and felted goods) constituted the principal branch of textile work in the Batley and Dewsbury districts.

210. *Discovery of Methods of Utilizing Fibrous Waste Materials.*—The raw materials (Paragraph 24) selected in the spinning of the character-forming yarn of these manufactures, were primarily employed in this country, as the mechanism was also invented here for the preparation of such materials into a suitable type of warp or weft thread. This is equally significant of the classes of fibre employed in the production of union dress and light textures (alpaca, mohair, and lustre wools) as in the composition of low woollen fabrics (noils, mungo, shoddy, "waste," "extract," etc.). Alpaca, as the basic material in lustre fabrics, was commercialized by Sir Titus Salt in 1836; and the combing, drawing, and spinning machinery requisitioned in converting it, and also mohair and lustre wools, into yarn, was originally designed and constructed by English inventors and machinists. Mungo and shoddy—the preparation and spinning of which rendered the low-class woollen industry a practical reality—were, in the first instance, recovered from disused or waste fabrics by Yorkshire manufacturers, and re-employed by them in new loom-made productions. The invention of the rag-grinding machine demonstrated that materials, hitherto conceived as necessary waste products, were reclaimable and also applicable, by the organization of fresh schemes of manufacture, to the fabrication of an extensive diversity of woven unions, especially in medium and heavy cloths. It became evident that, with the aid of this form of mechanical contrivance, all sorts of old or new cloth clippings, patterns and samples, as of oft-worn garments (mere rags and tatters), could be reduced to a fibrous state, and, therefore, to a re-usable substance.

211. *Waste Fibre in Manufacturing Processes.*—Before the introduction of shoddy and mungo, "milling," "raising," and "cutting" flocks, also "flyings," and "carding waste," had entered into economic textile manufacture and practice, but not as substitutes for wool. "Flocks," acquired in the

operations of scouring, dyeing, fulling, raising, and cropping, were selected for various purposes as in thickening the piece in felting by "flocking," that is, the milling of loose flocks, placed in the fulling stocks or mill, into the body of cloth; also for upholstery work, and, in the case of cutting flocks, in the production of flock wall-papers. No attempt, however, appears to have been made to use them to any important extent in yarn manufacture. But, being obtainable in considerable quantities in the white and in certain clean, standard colours—*e.g.*, those derived from the milling and raising of blankets, rugs, and kerseymeres—they comprised a useful material for adding weight to, or for modifying the shade of, the woven piece in the process of felting; and they still have these applications in the finishing treatment of woollen as well as of union manufactures.

212. *Recovery of Filament from Spun Yarns and from Union Fabrics.*—The two varieties of fibrous substances to be finally recovered were (1) the "twits," "ends," "knots," and "thrums" of woollen and worsted yarns from the processes of spinning, winding, warping, and weaving; and (2) the animal fibre in union textures composed of cotton and wool, cotton and alpaca or mohair, cotton and vicuna or camel's hair, etc. For "pulling" the first of these into a flossy substance, the Garnett machine—universally applied for the opening of this sort of waste—was invented. For recovering the wool or animal fibre from the union fabrics specified, the chemical process of carbonizing was introduced, and resulted in the material known as "extract" wool.

213. *Establishing a Distinctive System of Carding.*—A serviceable and varied range of re-manufactured fibrous products was thus provided, on which the union branches of the textile industry were fashioned and developed. It should be observed that all the "recovered" varieties of fibre referred to, both on account of their condition and shortness of staple, involved the practice of a distinctive grade of carding and spinning from that applicable to the preparation and treatment of

pure or natural wools. Classification and sorting of the reclaimed materials also assumed the character of technical arts, but the success achieved was mainly due to carding efficiency. In this work, the manufacturers of the heavy woollen districts of the West Riding of Yorkshire, collaborating with the textile engineer and machinist, evolved a system of carding and condensing for the manipulation and mixing of these fibres which has become pre-eminent. Continental producers have sought to effect innovations and improvements based on English ideas, methods, and routine. But the design and arrangement of the mechanical equipment, as understood by an effective set of Yorkshire carding engines for mungo and shoddy, combined with the standardized " counts " of card clothing, devised as the result of organized practical investigation, and of experiments in the systems of setting and running—have held the field.* In America, France, Russia, Belgium and Germany, as in this country, the whole scheme of work has been found to attain the fundamental essentials in carding procedure—a maximum amount of opening and blending compatible with the full degree of production, and a minimum quantity of fibrous waste. Continental inventors have exercised marked ingenuity in the origination and planning of devices for the reduction of the carding surface, with the object of gaining higher productive capacity; in changing the length, angle, and flexibility of the card wire; in speeding up different parts of the machines; and in condensing to a greater length, but so far their efforts have not contributed to the efficiency of, or modified, the leading principles and features of the system which the Yorkshire manufacturer, and English machinist, have established, by practice, as peculiarly adapted to the preparation of yarn from materials of the mungo and shoddy variety.

214. *Union Cloth Construction.*—As the British producer has thus led in economic yarn production, he has also excelled in cloth construction and manufacture. Acquiring, by

* See *Woollen and Worsted*, Chapter III.

experimental study, the requisite technical data relative to weave structure and loom setting, he attained proficiency as a maker of cloths from "wool substitutes," interwoven with cotton, satisfactory in firmness, durability and wearing property. Milling practice, to acquire substance and tensile strength of texture, was thoroughly investigated and mastered. New inventions, particularly in the form of apparatus combining the action of the milling machine and of the fulling stocks, were utilized; and, in addition, definite progress was made in finishing methods and routine, securing a superior handle and quality of piece.*

Weaving ingenuity and originality in design were not wanting. Union worsteds—mungo and cotton wefts and worsted warp—as well as union woollens—cotton warp and mungo or shoddy weft—were successfully produced. Moreover, at the time when matelassés were in demand for the mantle trade, both the warp and weft schemes of figuring were applied, in dobbie and harness looms, in the manufacture of distinctive designs and builds of fabric.

215. *Incompleteness of Dyeing Procedure.*—These facts suggest and illustrate manufacturing initiative and performance, impregnated with technical knowledge and faculty. Yet, it must be allowed that, until the discovery and practice of modern methods of dyeing animal and vegetable fibres, when made into the same yarn or woven product, this resourceful branch of textile production was seriously handicapped. A distinguishing feature, and salient idea, in the process of manufacture in the union cloth trade, is to acquire fabrics which, for commercial purposes, closely resemble corresponding makes of texture composed of pure wool, imitating colour, style and finish. This task was rendered increasingly difficult, and in some varieties of cloth almost impracticable, owing to the complications and uncertain results arising in the treatment of the sorts of fibre, in the yarn or fabric condition, by the old system of dyeing. Shade matching, in the separate

* See *Finishing of Textile Fabrics*, Chapter VII.

materials, was more or less an indefinite quantity, and the production of colour quality and evenness a constantly recurring problem. The absence of exact and scientific procedure in dyeing, was the primary and substantive cause of the origin, and also of the continuance of these unsatisfactory conditions.

216. *Class and Grade of Union Trading.*—With the manufacture of the cotton warp and mungo weft "beaver," Devon "pilot," and "president," it was clearly demonstrated that "quality," as defined by a face or fibrous finish, was obtainable, to a remarkable degree, in union cloths. True, the fabrics quoted are typical of heavily-milled structures, firm and thick in build and produced chiefly in black, navy blue, dark green, olive and brown. Delicate or soft-toned shades were correctly judged as unsuitable for application to such cloths. But the fact that highly-finished face union textures could be thus made showed that, with improved dyeing methods, the class and grade of trading in cotton-warp and low-woollen-weft fabrics would become greatly extended. Now this trading is equally diversified in textural results, and in volume of manufactured products, with that in Cheviot and Saxony yarns, and, in some of its modern phases, it overlaps the Crossbred and Botany worsted industries.

217. *Single-Weave Unions and Concealment of the Cotton-Warp Yarn.*—The technicalities in yarn construction, in weaving, and in dyeing and finishing, are of a specific character. Though, in the union woollen, the weft is made of all species of wool substitutes yet it consists of animal fibre, and, as such, is the yarn on which the features of the finished fabric are formed. The cotton thread, whether used in the warp or weft, is utilized as a binding yarn, and is not intended to have any textural effect. Its function is to interlace with the woollen and produce a fast, wearable structure, and to this function, in the making of the fabric, it is invariably restricted.

The cloths are single, backed and compound in formation, but designed with a view of concealing the cotton in whatever

capacity it may be employed. In single weaves this is effected by the difference in the diameters of the wool-fibre and the cotton-fibre yarns, and also by the relative number of threads per inch, in the piece, of each yarn unit. There are also other elements which contribute to the complete concealment, in the finished cloth, of the cotton, as may be shown by considering the manufacturing features typical, say, of a cotton warp and mungo weft melton. Such a fabric would be plain woven and set from 84 to 90 in. in the reed for a finished width of 54 to 56 in. In the "loom-felled" piece, the intersections of the cotton ends and of the woollen picks are alike visible, but the latter to a fuller degree than the former, or as defined by the ratio of their diameters. In scouring important changes occur; the cotton becomes less traceable, the individual distinctiveness of the picks is lowered, and the upper and lower surfaces of the fabric are freely covered with loose but entangled wool filament. Proceeding to felt the piece, the threads of warp are drawn into closer and closer relation, strengthening the fabric in the proportion of the added number of warp threads per inch; and the picks of weft contract lineally, thickening the cloth in the ratio of their diminished length. Assuming 32 ends of 2-fold 40's cotton (diameter $\frac{1}{120}$th of an inch), and 30 picks per inch of 10 skeins (diameter $\frac{1}{42}$nd of an inch), mungo yarn in the weaving of the fabric, the conditions induced in milling are responsible for the origination of the following textural characteristics—

I. Width contraction, from 90 to 56 in., adds 19·5 ends per inch to the fabric, the loom-set texture containing 32 and the felted cloth 51·5 threads per inch. II. The contraction to this degree of the piece reduces each line of weft by 34 in., and results, therefore, in 2,700 in. of weft yarn (30 picks × 90 in.) being compressed into 1,680 in. (30 picks × 56 in.) in one inch of the fabric. III. Each side of the cloth is, in the process, covered with woollen yarn, the angular curves of the picks protruding above and below the cotton ends, so

that the latter are centrally embedded in the fabric structure. IV. A piece of a cotton-warp and woollen-weft character is changed to one of a woolly nature, and, in appearances, to one formed purely of woollen yarn ; and V. a comparatively loose-woven production, with the yarn units separate and distinct, is converted into a firm, thick cloth of improved tensility, filament density, and fulness of handle.

From this dissection of the manufacturing principles, and results, illustrative of this type of woven union, it will be clear how, in all single-make cotton-warp and woollen-weft

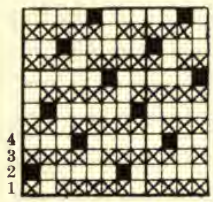


Fig. 190

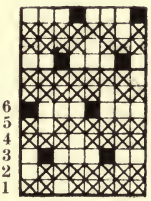


Fig. 191

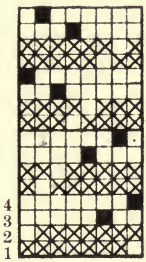


Fig. 192

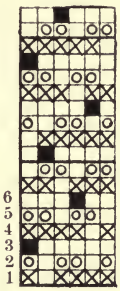


Fig. 193

fabrics—thin, medium or heavy in weight per yard, *e.g.*, habit cloths, beavers, blankets, rugs, etc.—the woollen yarn adequately conceals the threads of the cotton warp, and forms the yarn unit in the piece which gives the textural quality and value.

218. *Four Structural Types of Thick Manufactures.*—Thick, substantial union manufactures are divisible into four descriptions of fabric structures, namely—

I. Two- or Three-ply Weft Type.—Cotton warp and wool-substitute weft.

II. Two- or Three-ply Weft Type.—Worsted warp, cotton *face* weft, and mungo or shoddy *backing* weft.

III. Warp-backed Structures.—Worsted-*face* warp, woollen, worsted or cotton *backing* warp, woven with worsted or woollen and cotton weft yarns.

IV. Compound or Double- and Three-fold Cloths.—Worsted or woollen *face* and *backing* yarns in warp and weft, combined with a layer or series of centrally-disposed cotton threads or picks; or cotton threads and picks producing an intermediate fabric between the texture forming the face and the texture forming the reverse side of cloth.

219. *Weight-per-Yard Compass.*—Each group of structures is adapted for the production of fabrics ranging in thickness and substance from 20 to 48 oz. per yard, 54 in. wide. Groups I, III, and IV are, as a rule, set in the loom for heavy milling, and for yielding cloths suitable for either a rough or face finish, that is, for manufactures with a full filament surface. Group II includes the worsted variety of union, or a class of fabric in which the worsted warp is a pronounced characteristic. This being so, a less degree of felting is applicable than to the cloths in Groups I, III and IV. Still, the pieces should be set sufficiently wide in the reed to provide for the requisite amount of width shrinkage which will enable a nap of fibre to be successfully acquired, by raising, on the underside of the fabric.

220. *Examples in Two- and Three-Ply Weft Cloths.*—Examples of the first type of structures comprise the following makes and builds of fabric—

Two-ply Structures

Figs. 190 and 190A.—Six-end weft sateen face and back, woven 1 pick face and 1 pick back.

Figs. 191 and 191A.—Eight-end weft sateen face and 4-end weft swansdown back, woven 2 picks face and 1 pick back.

Figs. 192 and 192A.—Eight-end weft twill face and 8-end weft sateen back, woven 2 picks face and 2 picks back.

Three-ply Structures

Figs. 193 and 193A.—Six-end weft sateen face and back and prunelle twill centre, woven 1 pick face, 1 pick centre, and 1 pick back.

Figs. 194 and 194A.—Eight-end weft sateen face and back and cassimere twill centre, woven 1 pick face, 1 pick centre, and 1 pick back.

Figs. 195 and 195A.—Eight-end weft twill face and back and four-and-four twill centre, woven 1 pick face, 1 pick centre, and 1 pick back.

Figs. 196 and 196A.—Eight-end weft twill face, 8-end weft sateen back and plain weave centre, woven 1 pick face, 1 pick centre, and 1 pick back.

221. *Sectional Drawings.*—The sectional drawings, Figs. 190A to 196A, illustrate the different schemes of interlacing embodied. In each sketch the cotton warp ends are shown in circular spots, the face and backing weft yarns in black and tinted grey; and, in Figs. 193A, 194A, 195A, and 196A, the central picks are represented in two tones of medium grey. Apart from the "cover" acquired in the scouring and milling of the goods, or by compacting together the picks of weft in these processes, the plan of the weave type employed is instrumental in causing the threads of cotton to be hidden in the piece by the mungo or shoddy weft yarns.

Examining the two-ply structures, picks 1 and 3, Fig. 190 and 190A, form a weft surface and picks 2 and 4 a corresponding weft surface on the underside of the cloth. This build of texture results in an equal density of texture, as to shots per inch, on both sides of the piece; but it does not necessarily imply that the yarns for the face should be identical in quality with those for the back, though the yarns should approximately coincide in counts. Fig. 191 is differently arranged, the face effect being of a finer character than that developed on the back. Consisting of two picks of face to one pick of backing yarn, the former, as shown in the sectional drawing Fig. 191A, should be smaller in counts than the latter. With, say, 15 skeins yarn on the face weft, that of the backing should be about 10 skeins. To balance the difference in yarn counts, and also in the structural fineness of the two surfaces, the plan for the face is an eight-shaft sateen and that for the back a four-shaft weave, the length of the intersections thus agreeing with the ratio of the face and backing picks. This method of manufacture has economic advantages—admitting

of a lower grade of yarn being usable for the under than for the face side of the fabric, as, for example, a fine mungo weft for the picks marked in ⊠'s (Fig. 191) and a coarser quality of mungo or shoddy for the picks marked in ⊡'s.

222. *Possible Distinctions in Face and Backing Weaves.*— It is not absolutely essential, as will be observed from Fig. 192, that the weave effect should be identical on both sides of the cloth. In this example, it is a twill on the upper, and a sateen on the lower, side. While, however, some distinctions may be made in the two structures, the weaves, if equally distributed in the picks on each surface, require to correspond in the number of intersections of which they are composed. Taking Fig. 192, the eight-end twill and the eight-end sateen being grouped together 2-and-2 in the wefting, the scheme

FIG. 190A

of interlacing is, in both plans, seven warp and one weft on each pick. This rule of identity in interlacings is followed unless the two series of picks are dissimilarly classified in such orders as 2, 3, or 5 face to 1, 2, or 3 backing, when the plan of intersections in the backing weave is varied, in respect to that of the face weave, to acquire, as in Fig. 191A, a like compactness of textural surface on each side of the fabric.

223. *Three-ply Weft Structures.*—The three-ply weft structures (Figs. 193 to 196) introduce a supplementary series of picks, which, as in the instance of the face and backing picks in Figs. 190, 191, and 192, interweave with the cotton warp, but, instead of appearing on either one surface or the other of the cloth, produce a centre texture which adds to the strength and substance of the compound fabric. Such picks

FIG. 191A

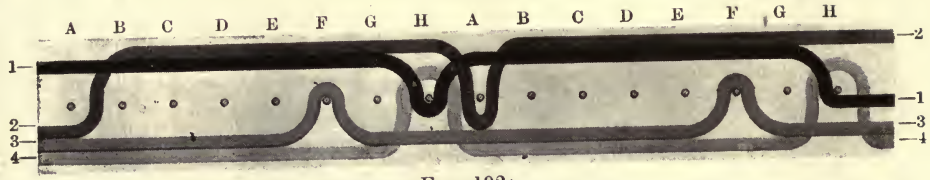


FIG. 192A

FIG. 193A

Picks 1 and 4 = Face
„ 2 and 5 = Centre
„ 3 and 6 = Back

A to F = Threads of Warp

are quite independent, as illustrated in Figs. 193A, 194A, 195A, and 196A, of the picks employed in the construction of the two sides of the woven piece. That is to say, they allow of the picks, sketched in black and in tinted grey, being arranged and grouped with the same freedom as in the production of two-ply manufactures.

Referring to the sectional drawings, they represent the orders of the intersections of picks 1 to 6 in Figs. 193 to 196 inclusive. The functions of the centre picks (in medium grey tones) is observed in making, in Fig. 193A, a prunelle twill fabric between two six-end weft sateen textures ; in Fig. 194A,

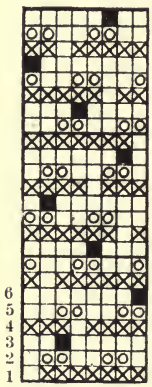


Fig. 194

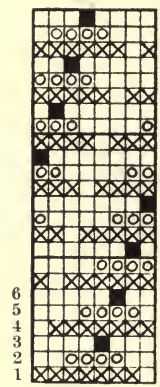


Fig. 195

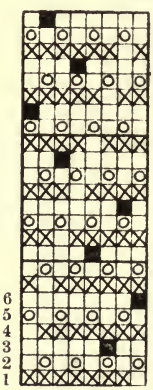


Fig. 196

a cassimere twilled structure between two eight-end weft sateen surfaces ; in Fig. 195A, a 4-and-4 twill fabric between two eight-end weft twill cloths ; and, in Fig. 196A a plain-woven structure betwixt an eight-end weft twill and an eight-end weft sateen surface. With the centre fabric thus varied in formation, it will be understood, there is some latitude in the selection of the counts and quality of the weft yarn for this purpose. Should the object be to obtain weight, tensility, and firmness of cloth by the use of the centre picks, rather than textural quality and fineness, then the weft yarn

may, if desired, be spun from vegetable fibre, relying upon the nature of the material used in the preparation of the face and backing yarns, for structural properties and value. In addition, the counts of this yarn may be such as to contribute a considerable quota of the total weight of the yarns in the fabric. Strictly, its diameter or thickness is chiefly limited by the adequacy with which it may be covered or concealed, in the woven and finished goods, by the yarns of the face and backing picks.

224. *Weaving Schemes—Multi-ply Weft Unions.*—These points and technical features, as well as the methods of manufacture adapted to the fabric structures analysed, are exemplified in the systems of looming applicable to the different weave types, and which are detailed in Table XXV.

225. *Analysis of Wefting Data.*—The wefting data for Fig. 190 produces one surface of the piece in carded and the other surface in combed yarn, and would result, with suitable finishing practice, in the two sides of the cloth differing in quality and in smoothness, that of the worsted being the brighter in tone. The plan of grouping the picks of the two wefts in Fig. 191 provides for a thicker and inferior class of yarn being woven on the back than on the face of the fabric, and also secures the production of a heavy cloth with a reduced number of picks per inch as compared with the 1-and-1 and 2-and-2 orders in Fig. 190 and 192. With a contrast in the character and structure of the weft and for the respective sides of the goods, such as mungo or Saxony yarn for face and shoddy or Cheviot yarn for backing, the two surfaces of the piece become finishable on different systems. Thus the arrangement in Fig. 192 is adapted for the development of a fine pile effect in the mungo, and a rough or nap pile effect in the shoddy yarn, for it is to be understood that, while both series of yarns interweave with the same warp threads, they, in reality, give two types of textures formed into one compound cloth structure. This enables the fabrics, which are con structed on the reversible principle of weaving, to be tinted

TABLE XXV

Weaving Schemes—Two-and-Three-ply Weft Unions.

Fig. No.	Warp.	Counts of Reed.	Width in Loom in Inches.	Weft.	Picks per Inch.	*Weight per Yd. in ozs. 54 in. wide.	Calculated Filament Composition of Fabric.
190	2/30's cotton	16's/2's	80	1 pick of 10 sks. woollen 1 „ 3's worsted	60	36	91% wool, 9% cotton
191	2/20's „	12's/4's	86	2 picks of 14 sks. woollen 1 pick of 7 sks.	64	35½	80% „ 20% „
192	2/20's „	12's/4's	86	2 picks of 16 sks. mungo 2 „ 16 sks. shoddy	80	30½	76% „ 24% „
193	2/30's „	14's/2's	80	1 pick of 12 sks. mungo 1 „ 3½'s cotton, soft spun 1 „ 12 sks. mungo	72	29	60% „ 40% „
194	2/20's „	16's/2's	84	1 pick of 8 sks.mungo or shoddy 1 „ 2½'s cotton, soft spun 1 „ 8 sks. mungo or shoddy	82	51	60% „ 40% „
195	2/20's „	15's/2's	75	1 pick of 10 sks. mungo 1 „ 3's cotton, soft spun 1 „ 10 sks. mungo	88	40	60% „ 40% „
196	2/20's „	15's/2's	84	1 pick of 3's worsted (Botany) 1 „ 2½'s cotton 1 „ 3's worsted (Crossbred)	84	59	66% „ 34% „
196	2/30's „	16's/2's	84	1 „ 7 sks. mungo 1 „ 2's cotton 1 „ 7 sks. mungo	72	51	61% „ 39% „
195	2/20's „	15's/2's	80	1 „ 5 sks. mungo 1 „ 2's cotton 1 „ 5 sks. mungo	66	57	68% „ 32% „
196	2/20's „	15's/2's	76	1 „ 3's worsted 1 „ 2½'s cotton 1 „ 3's worsted	70	45	65% „ 35% „

* Estimated on the basis of 60 yards of warp yielding 56 yards of woven piece, 55 yards finished, and a loss of 15 per cent. in the finishing routine.

FIG. 194A

Picks 1 and 4 = Face Picks 3 and 6 = Back
„ 2 and 5 = Centre A to F = Threads of Warp

FIG. 195A

Picks 1 and 4 = Face Picks 2 and 5 = Centre Picks 3 and 4 = Back

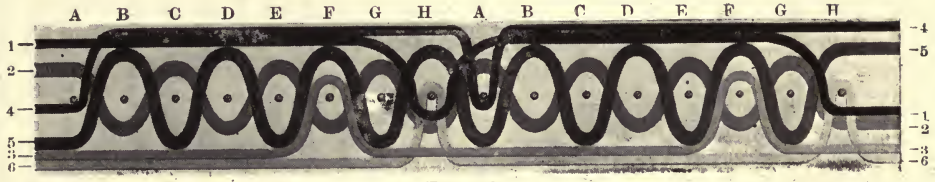


FIG. 196A

Picks 1 and 4 = Face Picks 2 and 5 = Centre Picks 3 and 6 = Back

and finished on either surface, as two separate pieces after the processes of cleansing and milling.

226. *The Use of Centre Weft Yarns.*—The three-ply structures suggest the use of the centre picks for strengthening and thickening the composite manufacture with cotton or a low quality of weft yarns, without detriment to, or alteration in, the substance and quality of the two surfaces woven in woollen or worsted yarn. The faster the central weave unit, the finer the build of the compound structure so far as it may be a resultant of the intermediate series of picks, which means that the plain intertexture in Fig. 196 would, all other technicalities being equal, improve the unfinished cloth tensility standard to a fuller degree than the $\frac{2}{2}^{1}$ twill order in Fig. 193 ; this weave than the $\frac{2}{2}^{2}$ twill in Fig. 194 ; and the $\frac{2}{2}^{2}$ than the $\frac{2}{2}^{4}$ twill make in Fig. 195. Such being the woven characteristics derivable from the central weave plan and picks, it might be assumed that the more frequent the intersections in this weave, the better it would be fitted for imparting soundness of construction to the multi-ply fabric. Other factors enter, however, into consideration. The fabric, both in structure and in appearance, is emphatically a resultant of the face and backing yarns. Hence the milling property of the cloth is controlled and determined by these yarns and by their system of grouping and interlacing. So are the handle and filament density and fineness of the surface of the finished product. On these textural features the central weave scheme may exercise a deleterious effect. In principle, the more open or looser the intertexture, the freer the shrinkage action of the woollen wefts, and, contrariwise, the faster the intertexture scheme the greater its tendency to restrain the felting movement of the face and backing yarns. It is a question of difference in the multiplicity of the intersections on the centre picks, for these, being cotton, form a neutral factor in the shrinkage value of the piece ; but, obviously, when their binding orders with the warp end are as in Fig. 196, they exert a more pronounced deterrent influence on the contractility of the woollen

wefts in the cloth than with the binding arrangements as in Fig. 195. The whole resolves itself into a problem of the degree of width shrinkage to be attained, and the degree of fabric or structural firmness it is sought to derive from the position in the cloth of the cotton weft yarn, when, as in the examples, the setting of the piece in the reed is made to conform with the textural features to be obtained in the finished manufacture, including thickness, tensile test, and weight per yard of the cloth.

227. *Colouring Practices.*—The manufacturing principles and data illustrated in Table XXV relate primarily to piece-dyed goods, but they are also applicable to loom-coloured fabrics. It has been indicated and explained that these structural schemes are usable in the production of cloths of different properties on the face and under surface, and therefore, adapted for distinctive finishing treatment. This factor demonstrates that the tinted tone of the two sides of the fabrics may, likewise, be different ; such as a light or medium colour for the face, and a dark mixture or contrasting shade for the back. Wool, worsted—Botany, Crossbred or lustre—as well as mungo and shoddy may be selected as the materials of which the weft yarns are made, so that the range of colouring in solid or mixture tones is variable and extensible with the class and style of goods manufactured. For example, in the better grades of production, with woollen and worsted yarns combined as in the wefting for Fig. 190, one surface of the cloth may be woven in white or any appropriate light tint, and the other in a bright, clear shade ; or the face may be in a medium and the back in a second medium or dark contrasting colour. In the construction of the mungo and shoddy weft-yarn fabrics, the toning is necessarily less diversified, but, here, as in the all-wool weft manufactures, fancy mixture yarns are also prepared and spun. Two bases of tinting become practicable ; first, in toned mixture shades, and, second, in the origination of individual mixture tints and tones. Taking, in illustration of the first basis, a series of mixture

shades graded from light to dark, the proportionate quantities of the material ingredients for a six-tone scheme would be as follows—

	Shade 1.	*Shade 2.*	*Shade 3.*	*Shade 4.*	*Shade 5.*	*Shade 6.*
Mungo, white or light tint .	90%	75%	55%	40%	20%	5%
,, black or dark shade .	5%	20%	40%	55%	75%	90%
,, Tinting hue in bright colour . . .	5%	5%	5%	5%	5%	5%

Applying this shade arrangement to Figs. 190 and 191, such tone groupings would be selected as mixtures 1 and 3, 2 and 5, and 3 and 6, for the face and backing yarns respectively, developing the two surfaces of the cloth in shades of corresponding tinted value but differing in tone depth.

The second basis may be exemplified by taking russet, citron, and olive, or the three tertiary hues, as the colour units, when mixture yarns in tints and shades, applicable to the different sides of the cloths, would be formable thus—

SHADES

A.	Material, Mungo or shoddy—Colour, Russet	50%
	,, ,, ,, with Black	50%
B.	Material, Mungo or shoddy—Colour, Citron	50%
	,, ,, ,, with Black	50%
C.	Material, Mungo or shoddy—Colour, Olive	50%
	,, ,, ,, with Black	50%

TINTS

A′.	Material, mungo or shoddy—Colour, Russet	50%
	,, ,, ,, with White	50%
B′.	Material, mungo or shoddy—Colour, Citron	50%
	,, ,, ,, with White	50%
C′.	Material, mungo or shoddy—Colour, Olive	50%
	,, ,, ,, with White	50%

228. *Application of Mixture-Yarn Shades.*—Such weft-shade assortments as the following would be feasible on this basis, in the practice of fabrication : (1) *Contrasts in tone*—A and A′, B and B′, and C and C′ ; (2) *Contrasts in hue, dark shades*—A and B, A and C, and B and C ; (3) *Contrasts in hue, light shades*—A′ and B′, A′ and C′, and B′ and C′ ; and (4) *Contrasts in both tone and hue*—A and B′, B and C′, and A and C′.

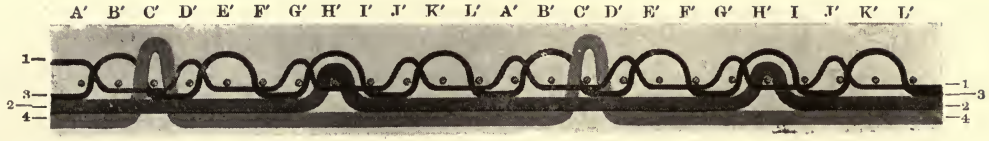


FIG. 197

Picks 1 and 3 = Face
„ 2 and 4 = Back

FIG. 198

Picks 1 and 3 = Face
„ 2 and 4 = Back

FIG. 199

Picks 1 and 4 = Intermediate Face
Pick 3 = Face
Picks 2 and 5 = Back

Considering that, in addition to the varied colour treatment which these schemes of mixture shade formation give, the two surfaces of the cloth, as pointed out, are weavable in dissimilar yarns, and that these provide for a different finished character on each side of the manufactured fabric, the two- and three-ply weft union structures are usable in the acquirement of goods diversified in style, quality, thickness, material composition, and also in weight per yard.

229. *Worsted Warp, Cotton and Woollen Weft Types of Fabrication.*—The second type of construction—Group II, Paragraph 218—is also two-ply in the weft and single in the warp. Whereas, however, in the first system of fabric build, the warp ends are covered by the two series of picks, now the warp yarns are made to conceal, on the face, the weft yarns with the backing picks (Figs. 197, 198 and 199) covering, on the back, complete groups of threads in the warping. Moreover, the warp is here changed to worsted, and interlaced, for the formation of the face effect, with picks of cotton yarn, but with woollen picks for the production of the backing texture. In a sense, this species of compound union is the inverse of that typified in Figs. 190 to 196, for the *warp* and not the *weft* is the salient feature of the upper surface of the fabric. In a second sense, namely, in respect to the under side of the cloth, the two schemes correspond, inasmuch as in both structures the weft, used as backing, floats in a sateen or twilled order. The three examples, for which sectional drawings are supplied, consist of weave units arranged thus—

FIG. 197.—COMPLETE PLAN ON 12 THREADS AND 24 PICKS

Pick 1 = $\frac{2 \quad 2 \quad 2 \quad 2}{1 \quad 1 \quad 1 \quad 1}$ = Warp intersections.
= Weft ,,

,, 2 = $\frac{7 \quad 4}{1}$ = Warp intersections.
= Weft ,,

,, 3 = $\frac{1 \quad 2 \quad 2 \quad 2 \quad 1}{1 \quad 1 \quad 1 \quad 1}$ = Warp intersections.
= Weft ,,

,, 4 = $\frac{2 \quad 9}{1}$ = Warp intersections.
= Weft ,,

FIG. 197.—COMPLETE PLAN—(*contd.*)

Pick 5 = $\frac{2\quad 2\quad 2\quad 2}{1\quad 1\quad 1\quad 1}$ = Warp intersections.
= Weft ,,

,, 6 = $\frac{9\quad 2}{1}$ = Warp intersections.
= Weft ,,

,, 7, etc.

FIG. 198.—COMPLETE PLAN ON 10 THREADS AND 20 PICKS

Pick 1 = $\frac{4\quad 4}{1\quad 1}$ = Warp intersections.
= Weft ,,

,, 2 = $\frac{3\quad 6}{1}$ = Warp intersections.
= Weft ,,

,, 3 = $\frac{3\quad 4\quad 1}{1\quad 1}$ = Warp intersections.
= Weft ,,

,, 4 = $\frac{6\quad 3}{1}$ = Warp intersections.
= Weft ,,

,, 5 = $\frac{1\quad 4\quad 3}{1\quad 1}$ = Warp intersections.
= Weft ,,

,, 6 = $\frac{9}{1}$ = Warp intersections.
= Weft ,,

,, 7, etc.

FIG. 199.—COMPLETE PLAN ON 16 THREADS AND 48 PICKS

Pick 1 = $\frac{2\quad 1\quad 5\quad 1\quad 3}{1\quad 1\quad 1\quad 1}$ = Warp intersections.
= Weft ,,

,, 2 = $\frac{12\quad 3}{1}$ = Warp intersections.
= Weft ,,

,, 3 = $\frac{2\quad 2\quad 2\quad 2}{1\quad 2\quad 2\quad 2\quad 1}$ = Warp intersections.
= Weft ,,

,, 4 = $\frac{3\quad 1\quad 5\quad 1\quad 2}{1\quad 1\quad 1\quad 1}$ = Warp intersections.
= Weft ,,

,, 5 = $\frac{5\quad 10}{1}$ = Warp intersections.
= Weft ,,

,, 6 = $\frac{2\quad 2\quad 2\quad 2}{2\quad 2\quad 2\quad 2}$ = Warp intersections.
= Weft ,,

,, 7 = $\frac{4\quad 1\quad 5\quad 1\quad 1}{1\quad 1\quad 1\quad 1}$ = Warp intersections.
= Weft ,,

,, 8 = $\frac{14\quad 1}{1}$ = Warp intersections.
= Weft ,,

,, 9, etc.

230. *Diagramatic Examples.*—On examining and comparing the diagrams illustrative of the two principles of intertexture, the technicalities in which they differ and coincide will be apparent. In the first series, the warp threads, A, B, C, etc., are quite hid by the face as by the backing picks, giving (as calculated on the intersections, in Fig. 190), 5 parts of weft to 1 part of warp, and, in Fig. 191, 7 parts of weft to 1 part of warp yarn on the face ; but, in the second series, the arrangement is transposed, the interlacings on the warp threads A′, B′, C′, etc., in Fig. 197, resulting in 2 parts of warp to 1 part of weft, and, in Fig. 198, in 4 parts of warp to 1 part of weft yarn forming the right side of the fabric. When the backing textures are analysed, the points in which the two systems have a *like* basis are observed ; for, in the first of these structural types, the backing picks in Fig. 190 float under 5 and over 1 warp thread, and, in Fig. 191, under 3 and over 1 ; and, in the second type of fabrication, the backing picks, in Fig. 197, float under 11 and over 1 warp end in succession, and, in Fig. 198, under 9 and over 1 warp thread in alternate order ; that is to say, in both schemes the picks, sketched in grey tones, produce a weft structure on the reverse side of the woven piece.

231. *Setting Practices.*—Another factor in which the two classes of textural product differ is the methods of setting or looming practised in each. The suggestions in manufacturing data, in Table XXV, indicate that in Figs. 190 to 196, the warp is comparatively loosely set in the reed with the structures firmly or closely woven in the weft. The excess of picks over threads per inch, is a fundamental feature in the weaving of the fabrics, affecting the density or " cover " of the weft surface, whether face or backing. To acquire thread density or compactness and, therefore, warp " cover " in Figs. 197, 198, and 199, the reed setting is finer than the wefting setting, as will be observed in the standard basis of looming for these, and like varieties of fabrication, given on the following page.

FIG. 197. *Warp.*

2-fold 48's worsted.
16's reed 6's.

Weft.

1 pick of 2-fold 40's cotton.
1 ,, 12 skeins mungo.
48 to 54 picks per inch.

FIG. 198. *Warp.*

2-fold 60's worsted.
20's reed 6's.

Weft.

1 pick of 2/40's cotton.
1 ,, 10 skeins mungo.
60–64 picks per inch.

FIG. 199. *Warp.*

2-fold 56's worsted.
19's reed 6's.

Weft.

1 pick of 16's cotton.
1 ,, 8 skeins mungo.
1 ,, 2/56's worsted.
56 picks per inch.

232. *Cloth Quality in Bi-Wefted and in Cotton and Worsted Warp Unions.*—Cloth quality, in the cotton-warp and woollen-weft backed structure, is largely a resultant of milling, raising, and finishing practice. Cloth quality in the worsted warp and woollen-and-cotton weft union is, on the contrary, chiefly acquired in the loom. The measure of width-shrinkage in the former, produces, as shown, a pile or nap of filament in the piece and imparts softness and thickness to the finished texture. There is no corresponding milling contraction in the treatment of the two-ply weft and worsted-warp variety of union, the cloths not being set more than 63 to 66 in. wide in the reed, as contrasted with the reed dimensions of 80 to 90 in. specified in Table XXV for the cotton-warp build of fabric. The system of setting, plus the selection of Botany worsted yarn for warp and the bringing of the warp threads

on to the face, first, by the plan of the weave, and second by the ratio of threads to picks—see the looming particulars, page 320—are the basic technicalities on which the fine effects and structural features, characteristic of these manufactures, are formulated.

The soft fibrous backing, which should also distinguish the goods, is due to flushing the mungo or shoddy yarn freely on the back, and shrinking the pieces slightly, either in scouring or for a short period in the milling machine. In the process, the worsted and woollen yarn surfaces are compacted one with the other, and a sort of filament nap is obtained on the under side of the piece. The raising of this, in a damp condition, transforms it into a smooth, level pile of fibres, thereby neutralizing the coarse nature and structure of the inferior backing yarn, and, at the same time, adding to the textural quality, flexibility, and wearing property of the goods.

233. *Two-Ply Warp Union Specimens.*—The principal variety of this class of union is constructed on the warp-backed principle, combining such warping orders as 1 thread of face, 2 threads of face, or 3 threads of face to 1 thread of backing yarn. The yarns for the under surface may be worsted, woollen or cotton, but those used for the face are invariably worsted or fine woollen. For weft, cotton, bi-fibred worsted or vigoyne carded yarn is usable, according to the class and grade of manufacture to be obtained. As a woven structural scheme, it is suitable for making a fast and firm build of cloth, one which, in the wear, retains its character and finish more satisfactorily than a single-weave worsted-and-cotton fabric of a corresponding fineness and weight per yard. The theory and practice of intertexture and fabrication involved, may be exemplified by assuming a textural type, that of a $\frac{2}{1}$ twill face (worsted) and an eight-end sateen back (cotton) or a two-ply warp cloth, arranged 1 worsted and 1 cotton, and crossed with bi-fibred worsted or cotton weft. Such a structure might be conveniently set with 104 threads and 52 picks per inch, should the yarn counts be 2-fold 48's worsted, 2-fold 40's

cotton, and equivalent to 20's single cotton in the shuttling. The cotton picks in this plan of weave and looming should be barely traceable in the woven and uncleansed piece; and, therefore, literally invisible in the finished product, for they only interweave 1 in 4 threads on the face and 1 in 8 threads on the back, or they actually pass between the two sets of

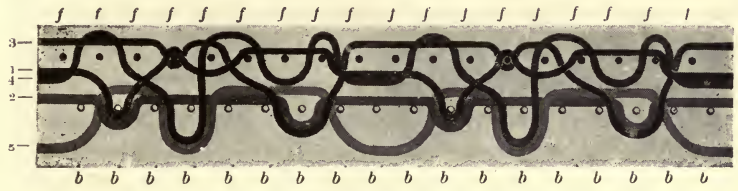


FIG. 200

f = Face Warp
b = Backing Warp
1, 3 and 4 = Face Weft
2 and 5 = Centre and Backing Wefts

warp yarn, effecting their knitting together, and the clear formation of the weave effects.

The right side of this class of union possesses the character and fineness of a solid worsted, but the reverse side is a pure cotton texture of the warp-sateen arrangement. The result is a compound cloth having the features and qualities of both

FIG. 201

wool and cotton, or a design and build of texture sound in construction, and of useful wearing serviceability in semi-tropical climates. The yarns, in its composition made of wool filament, lend softness and colour tone, while those made of cotton filament, supply firmness and durability, and wearing value as determined by coolness of fabric in combination with stability of woven structure.

234. *Productive Economics and Weave Plans.*—Economy in fabric materials and in production is one of the essential

factors to be attained in this grade of union manufacture. The textures may, as in the example described, be worsted-yarn face and cotton-yarn back, or worsted face, worsted or woollen back, and cotton centre. It will be shown that the basis of construction is applicable to the manufacture of the heavier grades of worsted unions, and that it yields a class of fabric which, while possessing a cotton yarn or bi-fibred yarn ingredient, has a worsted character and quality of handle. The structural build is illustrated sectionally in Figs. 200 and 201, the former having an eight-shaft weave on the face an a warp effect on the back, and the latter making a compound five-end twilled texture. The formulae for the design units and the data for the warping and weaving arrangements are specified below—

FIG. 200.—WEAVE FORMULAE COMPLETE ON 16 THREADS AND 12 PICKS

Pick 1 (face) $= \frac{1\ \ 3\ \ 1}{1\ \ 3\ \ 7}$ = Warp intersections.
= Weft ,,

,, 2 (centre and backing stitching) $= \frac{1\ 3\ 1\ 1\ 1\ 3}{1\ 1\ 1\ 1\ 1\ 1}$ = Warp intersections
= Weft ,,

,, 3 (face) $= \frac{1\ \ 1\ \ 3}{6\ \ 3\ \ 1\ \ 1}$ = Warp intersections.
= Weft ,,

,, 4 (face) $= \frac{1\ \ 1\ \ 2\ \ 1}{3\ \ 1\ \ 4\ \ 3}$ = Warp intersections.
= Weft ,,

,, 5 (centre and backing stitching) $= \frac{3\ 1\ 3\ 1\ 1\ 1}{1\ 1\ 1\ 1\ 1\ 1}$ = Warp intersections
= Weft ,,

,, 6 (face) $= \frac{3\ \ 1\ \ 1}{3\ \ 3\ \ 5}$ = Warp intersections.
= Weft ,,

,, 7 (face) $= \frac{1\ \ 1\ \ 3}{7\ \ 1\ \ 3}$ = Warp intersections.
= Weft ,,

,, 8 (centre and backing stitching) $= \frac{1\ 1\ 3\ 1\ 3\frac{1}{1}}{1\ 1\ 1\ 1\ 1}$ = Warp intersections
= Weft ,,

,, 9 (face) $= \frac{1\ \ 3\ \ 1}{2\ \ 1\ \ 7\ \ 1}$ = Warp intersections.
= Weft ,,

,, 10 (face) $= \frac{1\ \ 1\ \ 1\ \ 2}{4\ \ 3\ \ 3\ \ 1}$ = Warp intersections.
= Weft ,,

FIG. 200.—WEAVE FORMULAE—(*contd.*)

Pick 11 (centre and backing stitching) $= \frac{1\ 1\ 1\ 1\ 3\ 1\ 2}{1\ 1\ 1\ 1\ 1\ 1}$ = Warp intersections. = Weft „

„ 12 (face) $= \frac{1\quad 3\quad 1}{2\quad 5\quad 3\quad 1}$ = Warp intersections. = Weft „

„ 13, etc.

FIG. 200.—WARP

1 thread of 2-fold 44's worsted.
1 „ „ „ bi-fibred worsted.
21's reed 6's.

Weft.

1 pick of 2-fold 44's worsted.
1 „ 16's single (soft spun) cotton.
1 „ 2-fold 44's worsted.
74–80 picks per inch.

FIG. 201.—WEAVE FORMULAE, COMPLETE ON 11 THREADS AND 22 PICKS

Pick 1 (face) $= \frac{4\quad 1}{4\quad 1\quad 1}$ = Warp intersections. = Weft „

„ 2 (centre and backing stiching) $= \frac{1\ 1\ 1\ 4}{1\ 1\ 1\ 1}$ = Warp intersections. = Weft „

„ 3 (face) $= \frac{1\quad 4}{5\quad 1}$ = Warp intersections. = Weft „

„ 4 (centre and backing stitching) $= \frac{1\ 1\ 1\ 1\ 3}{1\ 1\ 1\ 1}$ = Warp intersections. = Weft „

„ 5 (face) $= \frac{1\quad 1\quad 3}{1\quad 5}$ = Warp intersections. = Weft „

„ 6 (centre and backing stitching) $= \frac{3\ 1\ 1\ 1\ 1}{1\ 1\ 1\ 1}$ = Warp intersections. = Weft „

„ 7 (face) $= \frac{3\quad 1\quad 1}{1\quad 5}$ = Warp intersections. = Weft „

„ 8 (centre and backing stitching) $= \frac{4\quad 1\quad 1\quad 1}{1\quad 1\quad 1\quad 1}$ = Warp intersections. = Weft „

„ 9 (face) $= \frac{4\quad 1}{1\quad 1\quad 4}$ = Warp intersections. = Weft „

„ 10 (centre and backing sticking) $= \frac{1\ 4\ 1\ 1}{1\ 1\ 1\ 1}$ = Warp intersections. = Weft „

„ 11, etc.

FIG. 201. *Warp.*
2-fold 36's worsted.
16's reed 6's.

Weft.
1 pick of 2-fold 36's worsted.
1 ,, 12's soft spun cotton.
96 picks per inch.

235. *Structural Arrangements and Fabric Substance or Thickness.*—Both these structures provide for the use of a cotton weft which passes between the face and backing threads, as is clearly indicated in the sectional sketches, Figs. 200 and 201. This yarn has also a second function, that of stitching regularly with the backing warp threads, and of forming, on the under surface of the fabric, a warp-twilled effect.

Fig. 200 is arranged 1 pick face, 1 pick centre and 1 pick face, and Fig. 201 is shuttled 1 face and 1 of backing or centre yarn. Lines 1, 3, and 4 in the plan of the former, represents picks of face weft, interlacing with the threads *f*, and binding periodically with the threads *b*. The grey lines 2 and 5 interweave with ends *b*, and, when not utilized in producing the twilled underneath texture, lie intermediate betwixt the upper and lower set of warp ends. Fig. 201 is constructed on the interchanging double-weave basis, warp threads *f* and *b* appearing successively, as seen in the sketch, on the right and reverse side of the piece. For obtaining a make of cloth in which the strain, in the wear, is evenly distributed on all the warp yarns, it is a sound scheme of manufacture, but it entails, in the production of the ordinary grades of fabrics, that only one thickness and quality of warp thread should be applied; whereas the arrangement of the weave plan for Fig. 200, allows of the use of dissimilar sorts of yarn for the face and backing respectively, hence in the warping specified for this example, two kinds of warp thread, worsted and bi-worsted (or cotton in cheaper goods), are combined.

For increasing the weight per yard of the textures, two methods of work are available; in the first instance, the cotton

weft may be changed to a union woollen of some 22 or 24 skeins, with a small reduction in the picks per inch; and, in the second instance, the pieces may be set from 66 to 72 in. wide in the reed, and a degree of felting practised. Using more open weave structures than those illustrated, and adapting fuller setting in the warping and the wefting, is a further means of adding to the weight per yard and substance of these types of union worsteds.

236. *Double-make Unions—Wadded.*—This compound weave variety of union is illustrated in Figs. 202 and 203. The first example consists of 2-and-2 twill face and back, with cotton-warp yarn centre, arranged in the warp, 1 thread face, 1 thread backing, 1 thread face, and 1 thread centre, and in the weft, 1 pick face, 1 pick backing, and 1 pick face. It results in a cloth of double the yarn density on the right as on the under surface. The second example is illustrative of fabrics in which the yarns are grouped 1 thread face and 1 thread backing in the warping, and 1 pick face, 1 pick backing, 1 pick face, and 1 pick centre, or wadding, in the wefting.

Figs. 202 and 203 are, clearly, double-make textures, strengthened and thickened, in the former, by the employment of a supplementary series of cotton threads, c^1, c^2, c^3, and c^4; and, in the latter, by the insertion of a special series of picks represented, in the sectional drawing, by the light grey line or shot 4. Such threads, or picks, are quite a separate and distinct yarn from the warp and weft threads combined in the formation of the face and backing textures. Their presence in the structure is not designed to have any modifying influence on either the upper or lower fabric in the compound cloth. They are strictly wadding yarns, and as such may be made of cotton or of an inferior quality of material, and be spun to a heavier counts than the worsted, woollen, or better sorts of yarn, used in the production of the face and backing textures. Both these systems of union construction are applicable to manufactures composed of (1) worsted or woollen warp and weft; (2) worsted face and woollen backing yarns; (3) fabrics

with a worsted warp and crossed with woollen weft, and (4) fabrics made of worsted yarn on the face and of woollen yarn on the back, using in each type of structure cotton threads for wadding and weighting purposes.

The binding of the different textural structures together is effected by the face warp ends interlacing, in regular sequence,

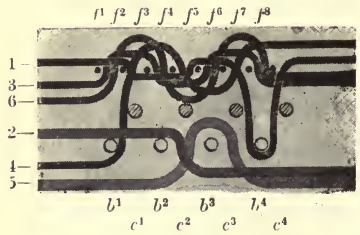


Fig. 202

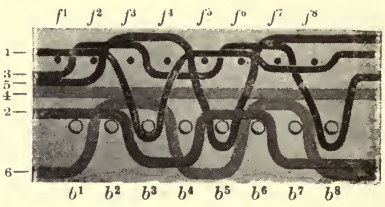
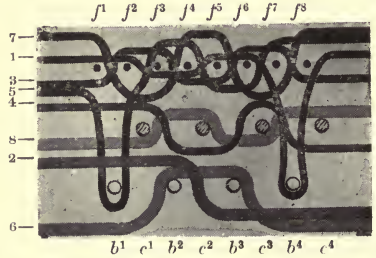


Fig. 203

with the threads of the backing warp, picks 1 and 4 in Fig. 202 binding with b^4 and b^1, and picks 1, 3, and 5 in Fig. 203 with b^3, b^8, and b^5. The grey lines, or backing shots, interweave with the ends b^1 to b^4; with the *cotton threads* c^1, c^2, c^3, and c^4 in Fig. 202, lying *uninterlaced* betwixt the face and backing textures; while the *cotton picks* in Fig. 203, as represented by the light grey line 4, also *uninterlaced*, form the central yarn feature of the double fabric. It will be understood that in a complete repeat of the weave plans, each set of picks binds in correct twill or sateen order with a separate group of backing threads, as, for example, in Fig. 203, where pick 1 stitches with thread b^3, 3 with b^8, and 5 with b^5; and in the picks not shown, 7 would stitch with b^2, 9 with b^7, 11 with b^4, 13 with b^1 and pick 15 with thread b^6.



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It should be observed that the centre-weft principle of inserting the cotton ingredient, facilitates the employment

of thick and soft wadding yarns—two- or multi-ply but untwisted—and that the centre-warp principle offers an economic advantage in piece weaving, inasmuch as it does not add to the shuttling factor, but it has the drawback of limiting the kind of yarn structure usable; for as the centre warp yarn is of necessity under tension in the looming operation, it requires to be of a fairly compact character, and also of a moderate tensile property.

The formulae of the weave units of the compound structures shown in Figs. 202, 203 and 204, are stated below—

FIG. 202.—DOUBLE-MAKE PLAN, WITH CENTRE WARP, COMPLETE ON 16 THREADS AND 12 PICKS

Pick 1 (face) $= \frac{1\ \ 1\ \ 3}{4\ \ 1\ \ 5\ \ 1}$ = Warp intersections.
= Weft ,,

,, 2 (back) $= \frac{1\ \ 3\ \ 10}{1\ \ 1}$ = Warp intersections.
= Weft ,,

,, 3 (face) $= \frac{1\ \ 1\ \ 1\ \ 2}{5\ \ 1\ \ 5\ \ 1}$ = Warp intersections.
= Weft ,,

,, 4 (face) $= \frac{3\ \ 1\ \ 1}{5\ \ 1\ \ 5}$ = Warp intersections.
= Weft ,,

,, 5 (back) $= \frac{5\ \ 3\ \ 6}{1\ \ 1}$ = Warp intersections.
= Weft ,,

,, 6, etc.

FIG. 203.—DOUBLE-MAKE PLAN, WITH CENTRE WEFT, COMPLETE ON 16 THREADS AND 16 PICKS

Pick 1 (face) $= \frac{3\ \ 1\ \ 1}{4\ \ 5\ \ 5\ \ 1}$ = Warp intersections.
= Weft ,,

,, 2 (back) $= \frac{1\ \ 1\ \ 5\ \ 1\ \ 4}{1\ \ 1\ \ 1\ \ 1}$ = Warp intersections.
= Weft ,,

,, 3 (face) $= \frac{1\ \ 1\ \ 1\ \ 1}{5\ \ 1\ \ 5}$ = Warp intersections.
= Weft ,,

,, 4 (centre) $= \frac{1\ 1\ 1\ 1\ 1\ 1\ 1\ 1}{1\ 1\ 1\ 1\ 1\ 1\ 1\ 1}$ = Warp intersections.
= Weft ,,

,, 5 (face) $= \frac{1\ \ 1\ \ 3}{1\ \ 5\ \ 5}$ = Warp intersections.
= Weft ,,

FIG. 203.—DOUBLE-MAKE PLAN—(*contd.*)

Pick 6 (back) = $\frac{3\ \ 1\ \ 5\ \ 1\ \ 2}{1\ \ 1\ \ 1\ \ 1}$ = Warp intersections.
= Weft ,,

,, 7 (face) = $\frac{3\ \ 1\ \ 1}{2\ \ 5\ \ 1\ \ 3}$ = Warp intersections.
= Weft ,,

,, 8 (centre) = Same as Pick 4.

,, 9, etc.

FIG. 204.—THREE-PLY PLAN, COMPLETE ON 16 THREADS AND 16 PICKS

Pick 1 (face) = $\frac{1\ \ 1\ \ 3}{4\ \ 1\ \ 5\ \ 1}$ = Warp intersections.
= Weft ,,

,, 2 (back) = $\frac{1\ \ 3\ \ 10}{1\ \ 1}$ = Warp intersections.
= Weft ,,

,, 3 (face) = $\frac{1\ \ 1\ \ 1\ \ 1}{5\ \ 1\ \ 5\ \ 1}$ = Warp intersections.
= Weft ,,

,, 4 (centre) = $\frac{1\ \ 1\ \ 1\ \ 3\ \ 1\ \ 1\ \ 2}{1\ \ 1\ \ 1\ \ 1\ \ 1\ \ 1}$ = Warp intersections.
= Weft ,,

,, 5 (face) = $\frac{3\ \ 1\ \ 1}{5\ \ 1\ \ 5}$ = Warp intersections.
= Weft ,,

,, 6 (back) = $\frac{5\ \ 3\ \ 6}{1\ \ 1}$ = Warp intersections.
= Weft ,,

,, 7 (face) = $\frac{1\ \ 1\ \ 1\ \ 1}{2\ \ 1\ \ 5\ \ 1\ \ 3}$ = Warp intersections.
= Weft ,,

,, 8 (centre) = $\frac{1\ \ 3\ \ 1\ \ 1\ \ 3\ \ 1}{1\ \ 1\ \ 1\ \ 1\ \ 1\ \ 1}$ = Warp intersections.
= Weft ,,

,, 9, etc.

237. *Union Compound Cloths with Outer and Inner Layers of Yarn.*—In A. Beaumont's improved double-make of union fabric, (Patent Specification, 18,056—1915), the inventor produces a woven two-ply manufacture made of two or more sorts or counts of yarn—composed of different materials, *e.g.*, cotton, woollen, worsted, angola, bi-fibred, etc.—with one yarn of a superior quality for giving textural character and handle, and the other of a lower quality, and employed in such a manner as to be rendered invisible. It is claimed that the

resultant loom product is similar in appearance and in feel to a texture formed of one kind or variety of yarn throughout. The construction of the double or combined cloth acquired, is built-up of an *inner* and of an *outer* layer of yarns, or of a *surface* and of an *interior* texture, the two being amalgamated into one structure solely by the method of interlacing the threads and picks of the inner with the outer woven tissue, the latter consisting of the better or higher class of yarn.

Instead of the two series of warp and weft threads, as in an ordinary double-build of cloth, being placed one over the other, or one series being confined to the face and the second series to the under or reverse side of the manufacture, the two fabric units, constituting the union production, are bound into one cloth by the warp and weft threads of the surface structure stitching through the composite fabric. Thus such yarns interlace alternately over and under the warp ends and weft shots of the inner texture, and pass through and through the central fabric formation, made of cotton or other suitable fibrous material. Each group of intersections of the surface warp and weft yarns, knits on the face and back of the double cloth. In accomplishing this, the surface yarns are given a larger float, or interlacing, than the threads of the warp and weft of the inner fabric, attaining the comparative concealment of the intermediate structure, with an appreciable degree of the manufactured features and quality of a cloth made of one yarn character and substance.

This scheme of union intertexture is further amplified (Patent Specification, 108,235—1917, A. and W. Beaumont) with a view of enabling, by the first method, every alternate *warp* thread to be hidden from view by the manner of interlapping the weft threads : and, by the second method, every alternate *weft* thread to be hidden by the plan of interlacing the warp threads. It follows that, in both arrangements, the interior or lower sorts of yarn in the cloth are effectively covered or concealed.

Common twills, simple weave elements, and various crossings, applicable to standard and special types of manufacture, are illustrated in the specifications quoted as formable on this textural basis, which is correctly conceived, and constitutes an efficient practice in union fabrication.

238. *Three-ply Manufactures Sectionally Illustrated.*—The third variety of example (Fig. 204) in which the cotton or other yarn elements are inserted into both warp and weft, and make an intermediate or centre texture, is typical of the three-ply build of woven manufacture. As in Figs. 202 and 203, the yarn composition of the structure is now variable, and the binding of the textural layers to each other is again accomplished by the picks of the face weft passing under the threads in the backing warp in a prescribed order, as indicated in the sectional sketch at b^1 and b^4. The cotton yarns—pick 8 and threads c^1, c^2, etc.—are, in such manufactures, utilized in the construction of a distinct type of fabric, namely, plain woven in Fig. 204 ; but this is subject to alteration with the function it is designed to have in the three-fold cloth. Obviously, the faster this structure, the fuller the degree of firmness it will originate in the composite textural result, so that its formation should be adapted, first, to the build and setting of the face and backing fabrics, and, second, to the technical features it is required to develop in the finished piece.

The classification of the yarns in the face, backing, and intermediate sections of the fabric, may be varied to agree with the nature and class of fabrication intended. That in Fig. 204 is 1 thread face, 1 backing, 1 face, and 1 centre in both the warping and shuttling, but other standard yarn groupings comprise : (*a*) 2 face, 1 backing, 2 face and 1 centre ; (*b*) 1 face, 1 backing and 1 centre ; and (*c*) 1 face, 1 backing, 1 face, 1 backing, and 1 centre. System (*a*) admits of the combination of small yarns and open weave types for the face, with thick yarns and fast weave types for the backing and centre ; system (*b*) of similar counts of warp and weft and weave plans in each of the three textures, face, centre, and

backing; and system (*c*) of the face and backing coinciding in yarn quality and diameter and also in plan of weave, with a plain or fine-twilled effect, produced in low counts of yarn, for the central feature.

The application of the several varieties of compound makes of union fabrics to the general and heavier grades of manufacture, has been chiefly considered in the structural schemes dissected and elucidated. References have been made in other portions of the work to figured textures in the production of which they are also employed, but decorative "unions," as likewise of fancy multi-ply woven textiles, composed of a number of distinctive yarn units, form a branch of technological study which can only be adequately analysed and illustrated in a separate and special treatise.

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Printed by Sir Isaac Pitman & Sons, Ltd., Bath, England
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